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DICTIONARY OF PHOTOGRAPHY

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Dictionary of Photography

A REFERENCE BOOK FOR AMATEUR AND PROFESSIONAL PHOTOGRAPHERS

Edited and largely re-written by

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PREFACE TO THE NINETEENTH EDITION

It is now over seventy years since the first edition of the DICTIONARY OF PHOTOGRAPHY was published, and even then it was not an entirely new publication. It was, in fact, a reprint, with some small additions, of an explanatory glossary of photographic terms that had appeared, in serial form, in *The Amateur Photographer* during 1888. In the hands first of its original author, the late E. J. Wall, and then of successive editors, the DICTIONARY has been kept continually up to date and gradually expanded to its present size. Naturally, very little is left of the original matter; nevertheless, working details, even if brief, of all older processes that have been of real value or importance in the past are still retained.

Much of the steady increase in size of the DICTIONARY has come about through the need to include new text to keep pace with the introduction of new equipment and new techniques; in addition, the articles dealing with the more important subjects have been expanded almost to the proportions of small handbooks. Several of these have been either entirely re-written or drastically revised for this edition; notable among them are the articles dealing with miniature cameras, sensitometry, and development, for in all three there have been considerable changes and advances since the appearance of the last edition. Many minor matters have been similarly dealt with.

This edition, like its predecessors, makes no attempt to report the work of scientists and research workers investigating the photographic process, nor to detail the many specialized techniques now so widely used in industry and research, for to be of any real value in either of these fields it would have to be expanded to very many times its present size. The DICTIONARY sets out only to cover ordinary general photography, as practised by the skilled amateur or the non-specialist professional, but within these limits it has been made as complete as possible.

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Preface

The main emphasis of the book continues to be on the practical side, but it does include enough of the scientific basis of the various matters discussed to give the photographer a real grasp of the essentials of the subject. Without this, he is likely to find himself helpless if faced with a difficulty, a failure, or even an unfamiliar task. Particular pains have been taken to make such more theoretical considerations as directly applicable as possible to practical problems, and in this connection the experience gained in answering many thousands of queries from readers of *Amateur Photographer* has proved invaluable.

It is perhaps too much to hope that the DICTIONARY is quite as complete as it is intended to be, for in compiling a book of so ambitious a character it is virtually impossible not to overlook some items, even if only quite minor ones, that ought to be included. It is not impossible, but only rather difficult, to make sure that such a book contains no errors or ambiguous statements; the Editor cannot find any, but others may. He will be grateful to hear of any omissions or errors that may be noticed, in order that matters may be rectified in a future edition.

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A.L.M.S.

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A

A. In chemical nomenclature, *a* as a termination has been widely used in the past to indicate indifferently the oxide or the hydroxide of an alkaline or alkaline earth metal; as alumin-*a*, lithi-*a*, potassi-*a*, stronti-*a*, or magnesi-*a*. Also as a termination for the names of alkaloidal organic compounds, as morphi-*a*, but in this latter case the syllable *-ine* is preferred, as morph-*ine*. As a prefix in scientific and technical names, *a* signifies negation, from the Greek privative prefix *a*; as "chromatic" having relation to colour, "*a*-chromatic" not having relation to colour.

Abaxial. In optics, not coincident with the axis. The term is applied to the oblique or marginal rays of light passing through a lens.

Aberration. Defects in the performance of a lens or mirror which prevent it from giving an absolutely sharp image. Complete removal of all aberrations is impossible, both theoretically and practically, but in a well-designed photographic lens the residual aberrations are small. The aberrations inherent in any optical system of transparent material with spherical surfaces are: chromatic aberration, spherical aberration, coma, curvature of field, astigmation, and distortion. (See under these headings.)

See also LENS.

Abrasion Marks. See STRESS MARKS.

Absolute. Pure or unmixed: often applied to alcohol almost entirely free from water. (See ALCOHOL.)

Absolute Temperature; Absolute Zero. Since the temperature of a body is the expression of molecular movements, complete withdrawal of heat would cause the cessation of these movements. The temperature at which this occurs

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has been accurately determined, and is approximately −273° C. (−459° F.). Since no lower temperature is possible, it is called the *Absolute Zero*, and temperatures reckoned from it, in Centigrade degrees, are called *Absolute Temperatures*. A temperature of 30° C. would thus be 303° A., and −30° C. would be 243° A. Sometimes written 243° K. to commemorate the work of Lord Kelvin. (See THERMOMETER and THERMOMETRY.)

Absorption. In optics, the partial destruction of light in passing through a medium: for example, a blue glass may absorb all rays but the blue rays, these latter being transmitted. Also the destruction of light by an opaque body, another form of energy (generally heat) being produced.

Accelerator. A term often applied to the alkaline constituent of a developing solution, because increasing the amount of alkali in all normal cases speeds up the action of a developer. The most commonly met accelerator is probably sodium carbonate, but potassium carbonate, and sodium or potassium hydroxides, are also used. Borax and sodium metaborate are now usually preferred in negative development; ammonia, once almost the standard alkali, has now dropped out of use completely. (See DEVELOPMENT and FINE-GRAIN DEVELOPMENT.)

Accessory Shoe. A socket, normally on the top of a camera, into which can be slid such accessories as viewfinders for lenses not of normal focus, flashguns, non-coupled rangefinders, and the like.

Acetate Film. Film in which the base, instead of the highly inflammable cellulose nitrate (" celluloid ") is of cellulose acetate, which, though it can be consumed by fire, will not flare up. This " non-flam " or " safety " base is used for substandard cine films, and for nearly all 35-mm. films for miniature cameras.

Acetic Acid (Fr., *Acide Acétique ;* Ital., *Acido Acetico ;* Ger., *Essigsäure*). Formula, CH_3COOH ; molecular weight, 60 ; synonym, Purified Pyroligneous Acid. The earliest known acid. In dilute form as vinegar by the fermentative oxidation of alcohol, but now largely prepared from wood by destructive distillation and subsequent purification. There are three commercial strengths.

Glacial Acetic Acid contains about 99 per cent. of acid and 1 per cent. of water. Its specific gravity varies from 1·065 to

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1·066. When cooled to 62° F. it solidifies into a mass of crystals, and remains solid till the temperature is raised. From this property is derived the term glacial. Care should be exercised in handling this, as it is distinctly corrosive; if any should by chance be spilt upon the naked skin, it should be washed off immediately. It is a poison, by reason of its caustic properties—the obvious chemical antidote being chalk or a bicarbonate. It is miscible with water and alcohol in all proportions. The glacial acid is highly inflammable.

Commercial "Strong" Acetic Acid. This is one-third the strength of the glacial acid, and contains about 33 per cent. of real acid. It can be conveniently prepared from the glacial acid by mixing with it twice its own quantity of distilled water. It is sometimes known as "Beaufoy's Acetic Acid," or "Acetic Acid B.P." Specific gravity, 1·044.

28 *per cent. Acetic Acid.* Acid of this strength, though not commonly sold in Britain, is specified in many American formulæ. It may be prepared by adding 3 parts (by volume) of glacial acid to 8 parts of water. Specific gravity, 1·0388.

Dilute Acetic Acid. Made by mixing 1 part of "strong" acid and 7 parts of distilled water, and sold as "distilled vinegar." Specific gravity, 1·006. It contains about 4½ per cent. of acid.

An easy way of approximately testing the strength of pure acetic acid is by determining the specific gravity by means of a hydrometer.

The chief photographic use of acetic acid is in hardening fixers and as an acid stop-bath for papers. It is also used in certain toners and intensifiers, and as a general-purpose mild acid.

Achromatic (*ἀ*, prefix signifying negation, and *χρωματικός* coloured), when applied to a lens, signifies that it has been substantially corrected for chromatic aberration, so that the focal length does not depend on the colour of the light being used. The correction is usually effected by combining two glasses having different dispersive powers, as, for instance, a convex crown-glass lens with a concave flint-glass, or by enclosing a flint negative between two crown positives. (See LENS.)

Acid Fixing Bath. A simple solution of hypo (sodium thiosulphate, $Na_2S_2O_35H_2O$) is completely effective as a fixing agent, but suffers from certain incidental disadvantages that have led to its virtual disappearance from photographic practice. Developers are almost always alkaline, but with

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the exception of amidol they lose their activity if made acid. In a plain hypo bath, developer carried over in print or film continues to act until it is washed out, so that development may continue unevenly if one print lies on top of another. Further, developer carried over will oxidise, so colouring the hypo bath and allowing stains to develop if conditions are favourable. And finally, the hypo bath, if much used, becomes alkaline, in which condition it has a strong tendency to soften the gelatine, increasing the likelihood of frilling, reticulation, blisters and mechanical damage.

Any but the weakest acid will decompose hypo, with the liberation of a yellow precipitate of finely-divided sulphur. This decomposition, which is enormously accelerated by rise in temperature, can largely be prevented if a sulphite is present. To acidify a fixer it is therefore usual to add to it either a mixture of sodium sulphite and an acid, preferably acetic acid, or a bisulphite, which behaves like a mixture of normal sulphite with free sulphurous acid. Excess even of bisulphite should be avoided, or sulphur may precipitate on standing in warm weather; as a safeguard, extra sulphite should be added, the bisulphite should be mixed with the hypo at or shortly before the time of use, and the quantity added should be carefully measured.

A standard acid fixer, suitable for both negatives and prints on contact, bromide, or chlorobromide papers, is:—

Hypo	4 oz.	(200 gm.)
Sod. sulphite (anhydr.) .	90 gr.	(10 gm.)
Potass. metabisulphite .	220 gr.	(25 gm.)
Water to	20 oz.	(1000 c.c.)

The solution should be cold when adding the metabisulphite, for which an equal weight of sodium bisulphite or metabisulphite may be substituted if preferred.

It should be noted that an acid fixing bath must not be used for printing-out or self-toning papers.

(See FIXING and HARDENING FIXER; also SODIUM BISULPHITE, HYPO, and STAINS.)

Acidity. Any solution containing more hydrogen ions than are found in pure water possesses the property of acidity, and will have a sour taste. The degree of acidity is estimated by determining the concentration of hydrogen ions in the solution, and is expressed as a *p*H value (*q.v.*). Paper impregnated

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with blue litmus is a common test for acidity, an acid liquid giving it a reddish tint. Alkalies or alkaline substances restore the blue colour.

Acids may be defined as compounds of hydrogen whose atom or atoms of hydrogen are replaceable by metals or by radicals having metallic characteristics, and the compound resulting from such substitution is termed a salt.

Actinic (*ἀκτῖνος*, genitive of *ἀκτίς*, a ray, especially of the sun). A term coined for the "chemically active" constituent of white light—that is, the blue, violet and ultra-violet by which alone the early sensitive materials were affected. In these days when practically all negative material is sensitive, if not to red, at least to all other colours, light of almost every colour is actinic. In connection with printing papers, which are not usually sensitised to colour, the term retains its original meaning, and it is correct to speak of an orange or red light as "non-actinic."

Actinograph (as above, with *γράφω*, I draw or write). Name given by Hurter and Driffield, the pioneers of sensitometry (*q.v.*) and inventors of the H. & D. system of stating plate speeds, to an early type of exposure calculator devised by them. (See EXPOSURE; EXPOSURE METERS.)

Actinometer (as above, with *μέτρον*, a measure). Any instrument which measures the intensity of the light by photographic means. The term Photometer (*q.v.*) is sometimes, but erroneously, applied to such an instrument. (See EXPOSURE and EXPOSURE METERS.)

Activol. Trade name used for colour developing agents marketed by Johnsons of Hendon. (See COLOUR DEVELOPING AGENTS.)

Adapter. An accessory enabling two pieces of apparatus not built for one another to be used together. A common example is an adapter enabling lenses meant for a screw-in flange to be used in a camera with a bayonet fitting; the adapter fits the camera and the lens screws into the adapter.

The term is used in a slightly different sense in a roll-film or film pack adapter; these replace the dark slide of a plate camera to enable roll or pack films to be used with it. Means for winding on the roll film, or changing the flat films of a pack, are incorporated in the adapter, which also has a light-tight sliding cover to enable it to be removed from the camera without fogging the film.

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Acutance. Term given to a property of a film by virtue of which it gives enlargements that appear sharp to the eye. The ability to do this depends more on the abruptness with which the density of the developed negative can change at the edge of a fine detail than on the actual resolving power (*q.v.*). The recognition of this fact has enabled many films to be improved in this respect, so that full advantage is obtained from the great sharpness given by modern miniature lenses. Acutance can further be enhanced by using a developer designed to accentuate edge effects. When such a developer, of which the Beutler developer (see BEUTLER METHOD) is one, is in use, any junction-line between a heavy and a light density is accentuated by increasing the heavy density and reducing the lighter one at the line where they meet. This increases the abruptness of transition from one to the other and increases apparent sharpness. The magnitude of the effect can be controlled during development; it becomes greater as agitation of the developer is reduced.

Adiactinic. (See ACTINIC.) An old term applied to red or yellow media for the dark-room window. No light is completely non-actinic. (See DARK-ROOM and SAFE LIGHT.)

Adurol. Obsolete trade name for mono-chlor-hydroquinone or mono-brom-hydroquinone. These were introduced by Lüppo-Cramer in 1899, and are more energetic than hydroquinone itself, and in particular are less susceptible to variations of temperature. Mono-chlor-hydroquinone is still available under the name chlorquinol (*q.v.*).

Aerial Fog. See FOG.

Aerial Perspective. A term used to denote the idea of distance conveyed in a landscape, or a photograph of one, by the progressive lightening of the more distant planes. This lightening is due to light scattered by the atmosphere and by dust-particles and water suspended in it, and is more marked in a photograph taken on a non-colour-sensitive emulsion than on one taken on a panchromatic emulsion using a filter.

Aerial Photography. The history of photography from the air goes back to 1845 when attempts were made to take photographs from non-navigable balloons. Nadar of Paris produced successful photographs from a balloon in 1858, but there was no real progress until fully controlled aircraft emerged from the experimental stage. With the First World

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War came the first attempt to make a science of map-reading from the air. In 1915 the forerunner of the modern Air Force camera appeared. Systematic aerial surveys of the sea and land were made, and maps of a new type followed. By the end of 1917 we had a complete photographic survey of the whole of Northern France and Flanders.

After the war aerial survey found its use in peace. The Royal Canadian Air Force, for instance, was given the work of surveying large tracts of land. In six years 40,000 square miles in Northern Canada, almost inaccessible to the ground surveyor, were mapped, and much valuable information was gained about the great forests, the different kinds of trees, and mineral deposits. In Australia the Government gave facilities for the Royal Australian Navy and the Royal Australian Air Force to survey the great Barrier Reef from the air. In South Africa, Northern Rhodesia was surveyed from the air to locate copper. In Britain archæologists unexpectedly found themselves owing much to aerial survey, for many buried features such as walls or earthworks betray their outline, when seen from the air, by small changes in the colour or vigour of vegetation. Usually these small changes are invisible, or at least unnoticeable, on the ground.

Air travel is now so usual that almost every camera-user has at least an occasional opportunity of taking pictures from the air, though on some international routes the use of a camera is, formally at least, prohibited.

The two main conditions likely to affect photography are the vibration of the machine and the rapidity, or otherwise, of its movement relative to the ground.

At heights of 1,000 feet or more the latter is so small as to call for no special precautions ; but vibration is a more serious matter. In the case of hand cameras, which is the only type an amateur is likely to use, it can only be combated by steadiness in holding.

It is of no avail to try to steady the camera by resting the arms or elbows against any part of the body of the machine, or to press the lens against the window of the cabin. Any such action merely brings the camera into closer contact with the framework of the machine, and so increases the amount of vibration. Held clear of all parts of the aeroplane, the camera is to some extent insulated from vibration by the body of the photographer, who acts as a shock-absorber.

In the ordinary cabin machine, it is quite satisfactory to photograph through the window so long as this is reasonably

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clean. Small specks of dirt on it will be so far out of focus as to be quite invisible on the negative. The presence of the glass is only harmful when the sun shines on it; even apparently clean glass will then scatter so much light as to make foggy degraded negatives a certainty.

In an open cockpit machine it must be remembered that the rush of air or "slip-stream" from the propellers is very considerable, and persons unused to flying may find their movements considerably hampered when they leave their seats, and forsake the shelter of the windscreen, in their efforts to hold the camera over the side. The instrument must be gripped as tightly as possible, and the more attention that is paid to holding it rigid and steady by muscular power independent of supports, the better the results are likely to be.

Exposures of $\frac{1}{200}$ sec. or $\frac{1}{250}$ sec. have been found to be short enough to obtain negatives reasonably free from blur and movement, so there is no necessity to employ the highest speeds of a focal-plane shutter: as, though the aeroplane may be progressing through space at a considerable speed, its movement relative to terrestrial objects appears small, unless one is flying very low indeed. If movement shows in a negative it can almost invariably be traced to faulty handling of the camera.

Types of Instruments Most Suitable.—In a cabin machine any camera fitted with a sufficiently rapid shutter can be used with some success, but it is to be noted that reflex cameras of any type are extremely awkward to use unless they are equipped with some kind of direct-vision finder.

In an open machine conditions are more difficult, and the rigidly-built miniature, without bellows, is perhaps the best. On any large camera the air-pressure is so great as to make proper control of the instrument difficult, and cameras have been known to be blown out of their owner's hands. The wind-pressure is such that it is liable to blow in the bellows of a camera sufficiently to cause part of the picture to be cut off, or even to shut the lens off entirely from the film.

Direct-vision viewfinders are the only satisfactory pattern, either the concave-lens or the open-frame types being suitable.

With fast lenses, a lens hood is very desirable; but in an open machine detachable patterns are so likely to carry away that their use is hardly possible.

A position should therefore be chosen so that sunlight does not shine into the lens. The lens can always be focused

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for "infinity." This setting should be checked periodically, as vibration has been known to upset the setting of a focusing mount after a time.

Height and Atmosphere.—Atmosphere is largely a matter of climate and season. Often in hot weather visibility at moderate heights may be fair from the visual point of view; but photographically hopeless owing to bluish haze, which may or may not prove penetrable by the use of a panchromatic film and a deep filter. In bad cases infra-red films may be tried.

As the intensity of haze usually increases with height, it is, as a general rule, best to photograph from the lowest practicable altitude.

In taking a ship, building, or some such prominent object, 1,000 feet is sufficient, although to encompass a town, or large area, considerably greater height may be required.

Exposure and Development.—Determine the exposure by any standard meter, bearing in mind the open nature of the subject and total absence of foreground.

The "distant landscape" factor in exposure calculators, or in tables such as those included under EXPOSURE, will give a satisfactory estimation.

Development calls for no special comment except that the time should be rather longer than usual to compensate for the probably flat lighting of the subject.

See also GUN-CAMERA.

Aerograph. See AIR BRUSH.

Afocal Magnifier. Attachment for increasing or decreasing the focal length of a camera lens. It is called "afocal" because it has no focal length; parallel light entering it emerges still parallel. The principle is that of the Galilean telescope, and it can be used either way round; to enlarge the image, giving the effect of a long-focus lens, or to diminish it, giving the effect of a wide-angle lens. Afocal lenses are most often used in conjunction with cine cameras, the narrow angle of view of which makes the design of such attachments much easier.

A.I.B.P. Associate of the Institute of British Photographers (*q.v.*).

Air Bells, or Air Bubbles. Air bells in the developer frequently adhere with great tenacity to the gelatine film, and give rise to places of less density than the surrounding parts,

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or even to clear celluloid. In developing a print, or a plate or film, in an open dish, it is always advisable to pass the fingers over the surface when first covered with the developer, or a flat, soft camel's-hair brush may be kept for this purpose. If a brush be used care must be taken that it is well washed after use and does not come into contact with any chemical or foreign matter, which would cause streaks on the finished negative. In tank development of films, air bells can be broken by turning the reel, or by raising and lowering it once or twice in the developer. The most certain preventive of this trouble is to soak the plate, film or paper in water before development, or better still, to use a wetting agent (*q.v.*).

Air Brush. An instrument chiefly used by professionals, with which liquid colours can be applied as spray to enlargements and prints. Air is pumped by means of a foot-blower through a chamber terminating in a fine orifice, the liquid colour being led to the opening by a movable needle or fine tube, where it is converted into a fine spray by the blast of air. A portable air brush, similar in form to a pencil, is known as the aerograph. An air brush may be used in vignetting negatives and in painting backgrounds. The principle of the air brush has been applied to the coating of glass plates with emulsion and to the coating of paper with photographic preparations. With proper precautions and suitable adjustment of the fineness of the spray, it gives an even and not granular coating; but allows of adjustment by which any required degree of granularity can be obtained. An ordinary spray-producer, such as is sold by perfumers, may be used to coat paper with gum bichromate mixture, or any thin sensitive preparation.

The air brush is frequently employed by designers and workers in fabrics and pottery. Designs in many colours are blown on with the aid of stencils, and the effects obtained are very beautiful. Users of the air brush should note that the rubber tubing used to connect the brush and the air tank cracks after a time and causes leakages. The best red-rubber tubing should be fitted in its place and examined from time to time for cracks.

(See COLOURING PHOTOGRAPHS, also BROMIDE PAPER.)

Airgraph. A wartime air service, based on microfilm technique, introduced in May, 1941, to convey messages between Britain and H.M. Forces in the Middle East, and subsequently extended to cover many other routes. The

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messages were written or typed on special forms size 10 × 8 in., and handed in at a Post Office. After sorting, these forms were photographed on high-resolution 16 mm. film, the reduction in area being about 250–fold. The rolls of exposed film, which could be processed before or after arrival, were transported to their destination by air. From the tiny negatives special automatic enlargers produced prints, size 5 × 4 in., on bromide paper in the form of a continuous roll 4 in. wide. After processing in automatic machines, the strip was cut into single letters which were finally delivered by post. The service was discontinued in 1945.

Albada Finder. See VIEW-FINDER.

Albumen. A complex organic substance that can be obtained from both animal and vegetable sources. The purest form in which it can be obtained is the white of egg. Its chief photographic use was the preparation of albumenised paper (*q.v.*). It may be obtained commercially in a dry form, which is convenient for such purposes as the albumen substratum in process work.

Albumen Process. An old process by which very beautiful lantern slides may be produced. The plates are slower even than gelatino-chloride plates, but the delicacy of results, the fineness of the deposit and the transparency of the shadows give it a high place. Glass plates are first thoroughly cleaned by brushing with nitric acid and water, rinsed in distilled water, and allowed to dry spontaneously; they are then edged with solution of indiarubber in benzene, and coated with an old " sherry-coloured " collodion. As soon as the film has set immerse in distilled water till all greasiness has disappeared: it is then ready for albumenising. Take 10 oz. (200 c.c.) of the whites of new-laid eggs, from which the germs have been removed, and add gradually, with constant stirring, 1 oz. 20 c.c.) of distilled water, to which 30 min. (1·25 c.c.) of glacial acetic acid have been added. Cover with a piece of muslin, or soft linen, and set aside for twenty-four hours in a cool place. At the expiration of this time remove the coagulated scum, and filter the albumen, when it is ready for the iodiser.

Ammonium iodide	50 gr.	(2·3 gm.)
Ammonium bromide	5 gr.	(0·2 gm.)
Ammonia 0·880	35 min.	(1·5 c.c.)
Distilled water	1 oz.	(20 c.c.)

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Add this to the albumen, and filter. The plate is coated with the iodised albumen and drained, and a second coating of albumen applied. The plate is then allowed to dry spontaneously, or by a gentle heat, the latter being preferable. The plate is now ready for sensitising, and as in this condition it will keep indefinitely a stock may be prepared. The plates are sensitised in a dipping-bath as in wet collodion, the following being the sensitiser :—

Silver nitrate . . .	480 gr. (27·5 gm.)
Distilled water . . .	10 oz. (250 c.c.)
Glacial acetic acid . . .	1 oz. (25 c.c.)

Dissolve and add—

Potassium iodide . . .	2 gr. (0·11 gm.)

Shake well, allow to stand for half an hour, and filter. The plates must be sensitised in yellow or orange light, and should remain in the bath for about half a minute in summer to one minute in winter. After sensitising, place in a dish of distilled water for five minutes, wash under the tap, and dry. Plates thus prepared will keep, under proper conditions, for several weeks. The exposure, which should always be to daylight, will be about 30 to 40 seconds under a negative of average density. The developer is as follows :—

No. 1.

Pyrogallol	40 gr.	(4·5 gm.)
Acetic acid	35 min.	(4 c.c.)
Citric acid	12 gr.	(1·35 gm.)
Distilled water . . .	10 oz.	(500 c.c.)

No. 2.

Silver nitrate . . .	12 gr.	(1·35 gm.)
Citric acid	12 gr.	(1·35 gm.)
Distilled water . . .	2 oz.	(100 c.c.)

For use add two or three drops of No. 2 to No. 1. Before development give the film an edging of rubber solution, and place in a dish of warm distilled water for one or two minutes. Place the developer in a porcelain dish, and heat gently by the aid of a spirit lamp to 100° F. ; place the exposed plate in the hot developer, and the image will gradually appear and gain density, this being accelerated, if desired, by the addition of more No. 2. The developer must be maintained at the above temperature, although errors in exposure may

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be compensated for by using a developer of higher or lower temperature. When sufficiently dense it may be fixed in—

Hypo	1 oz. (165 gm.)
Water	6 oz. (1,000 c.c.)

or a 4 per cent. solution of potassium cyanide. These slides may be reduced or intensified by any of the ordinary methods ; though, for the latter process, mercuric chloride, followed by ammonia, gives the most satisfactory tones. The image may be toned with the old *sel d'or* bath, the following being a near equivalent :—

Hypo, saturated solution .	2½ oz. (100 c.c.)
Gold chloride . . .	1 gr. (0·1 gm.)

Or a platinum bath, consisting of a 1 : 500 solution of platinic chloride, may be used. After washing and drying, the slides will be ready for binding.

Albumen-Gum-Bichromate Process. A method of direct pigment printing closely related to the gum-bichromate process. Paper is first sized with glue hardened by the addition of alcohol and alum, and is then coated with a mixture of 12 parts of albumen and 5 parts of gum mucilage (gum 1, water 2) in which a suitable colour is rubbed up. Bichromate is added to this, and the paper is coated, printed, and developed as for ordinary gum-bichromate (*q.v.*).

Albumenised Paper. Sensitised paper prepared with albumen and salt. The following short directions will give some idea of the method of procedure :—Absolutely fresh eggs were generally recommended, but many professional albumenisers preferred stale eggs as giving a more even and lustrous coating. Crack each egg into a separate cup or measure before mixing with the bulk, so that in case of the yolk breaking the whole of the albumen may not be spoilt. Take out the germ of each egg. Every fair-sized egg will yield about 7 drm. (25 c.c.) of albumen.

Albumen	6 oz. (175 c.c.)
Ammonium or sodium chloride	60 gr. (4 gm.)
Rectified spirit . . .	96 min. (6 c.c.)
Distilled water . . .	1¾ oz. (50 c.c.)

Dissolve the salt in the spirit and water, add to the albumen, and beat with an egg-whisk for fifteen minutes ; allow it to settle and filter it through a tuft of cotton-wool, previously

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well washed with distilled water. This is sufficient for a quire. The paper should be either Saxe or Rive. Put the albumen into a large flat dish ; take the paper by two opposite corners, and bring the hands close together, so as to make the paper bow out in the middle ; lay the middle of the paper on the surface of the albumen, gradually lowering the ends till it rests on the albumen. When the paper has floated for a few seconds, bubbles will be shown by the numerous puckers ; lift the paper, and wet the bubbles with a camel's-hair brush ; allow the paper to float for eighty seconds—not longer, or the albumen will sink into the body of the paper—then gradually raise by one corner, and suspend from two corners to dry ; when thoroughly dry, roll between smooth rollers, and keep flat. Double albumenised paper is made by coagulating the first layer of albumen by floating on a mixture of two volumes alcohol and one volume of water. The paper is now dried and again floated on the salted albumen. The albumenised paper is sensitised by floating it, face downwards, on a solution of silver nitrate of strength about 13½ to 14 per cent., three or four minutes being sufficient. Very full instructions as to printing on albumenised paper are contained in some of the older books such as " The Art and Practice of Silver Printing," by Abney & Robinson, London, 1888. (See TONING, and also FUMING.)

Alcohol (Fr., *Alcool ;* Ital., *Alcool ;* Ger., *Weingeist, Alkohol*). $C_2H_5OH = 46$. A generic term ; but when used without qualification common or ethyl alcohol is understood. Synonyms : Rectified Spirit, Ethyl Alcohol, Ethyl Hydrate, Spirits of Wine. It is prepared by distillation from fermented saccharine solutions, or any vinous fluid. There are certain recognised strengths :—

Absolute Alcohol, which, as sold, may perhaps contain 1 or 2 per cent. of water. Specific gravity, 0·800.

Rectified Spirit, B.P. Alcohol containing 10 per cent. of water by volume, or 14½ per cent. by weight. It is 58° over proof. Specific gravity, 0·834.

Proof Spirit. Made by diluting five volumes of rectified spirit with three of water, and contains 49·3 per cent. of alcohol by weight, or 57·1 per cent. by volume.

Degrees over and under Proof. A spirit of 25° over proof is of such strength that when 100 parts by volume are diluted with water until the mixture is of " proof " strength, 125 volumes of proof spirit will be produced. A mixture described

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as 25° under proof is one of such a strength that each 100 volumes of it contain 75 volumes of proof spirit.

Alcohol, Methyl. An alcohol containing CH_2 less than ordinary or ethyl alcohol, and therefore having the formula CH_3OH. It is a chief constituent in the crude wood spirit used for mixing with ordinary alcohol for the constitution of the methylated spirit of commerce; when pure, methyl alcohol has not the characteristic taste and smell of wood spirit, but rather resembles ordinary or ethyl alcohol. Its specific gravity is 0·8142, and it boils at about 65° C. The purified commercial methyl alcohol may be used in most cases as a substitute for ordinary alcohol, but the crude wood spirit is generally a less desirable material to use. The main use of methyl alcohol is in concentrated developers, where it serves to keep the developing agent from precipitating out.

Alcohol, Methylated, or methylated spirit. This is rectified spirit to which various substances have been added to render it undrinkable, in consideration of which the Excise authorities allow it to be sold as a fuel without being subject to duty. At the present time the additions in question consist of 10 per cent. of crude wood spirit, one-eighth of 1 per cent. of mineral naphtha, from ½ to 1 per cent. of pyridine (which has an exceedingly unpleasant taste) and a trace of methyl violet to colour it. The naphtha appears as a milkiness when water is added.

Methylated spirit used to be recommended for accelerating the drying of negatives and prints, but the modern spirit contains oils which are liable to be precipitated in the emulsion when the spirit is mixed with water. Its use for this purpose is therefore to be avoided.

Aldehyde. A substance derived from a carboxylic acid by removal of one atom of oxygen. The only aldehyde used in photography is formaldehyde, the aldehyde of formic acid, which is sold as a 40 per cent. solution under the name FORMALIN, which see.

Algebra. Generalized arithmetic in which letters are used in place of figures. As a certain amount of information, chiefly in connection with lenses and optics, is presented in this book in the form of algebraic formulæ, a word on their use and interpretation may not come amiss. It is first essential to

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grasp that the letters in a formula mean nothing in themselves. Any formula is meaningless, even to a mathematician, until explicit meanings have been allotted to the letters comprised in it. Every formula is therefore accompanied by a careful definition of the letters involved.

Secondly, an algebraic formula apparently indicates that various letters have to be added, subtracted, multiplied, or divided. This, taken literally, is also meaningless ; except formally, arithmetical operations cannot be carried out with letters. The formula actually means that if, in any practical case, the corresponding figures are substituted for the various letters, carrying out the arithmetic as indicated will provide the required answer.

Under CONJUGATE FOCI we are told that, in enlarging, the distance from lens to paper is $(n+1)f$, and that n stands for the degree of magnification and f for the focal length of the lens in use. What the formula means is that in any practical case we have only to add " 1 " to the magnification and multiply the result by the focal length of the lens, and we shall have found the lens-to-paper distance we wanted to know. Enlarging 5 diameters with a 3-inch lens, the lens-to-paper distance will be $(5+1)\times 3=6\times 3 = 18$ inches.

The point is that the formula gives, in symbolic form, the answer, not merely to one, but to every conceivable combination of values for magnification and focal length ; it is a " potted " answer to *every* problem of this type.

To avoid confusion with the letter " x ", the multiplication sign " $\times$ " is seldom used. If a and b are to be multiplied together, the formula will read " ab ", not " a $\times$ b ". Addition, subtraction, and division are indicated exactly as in ordinary arithmetic.

If a letter is to be multiplied by itself (as $f \times f$, or 3×3). it is never written as " ff ", but always as " f^2 " (" f squared "). Similarly, " f^3 " (" f cubed ") means three f's multiplied together. Note, however, that " f_2 " does *not* mean $f \times f$; it is read as " f two ", and the " 2 " simply serves to distinguish this f from other f's in the same formula. f_1 and f_2, for example, may stand for the focal lengths of two different lenses.

Brackets often appear in a formula, and it is wrong to ignore them. Their meaning is the obvious one ; everything within a pair of brackets must be treated as one unit. $4 + 2 \div 3$ makes $4\frac{2}{3}$; $(4 + 2) \div 3$ makes 2. As this example shows,

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figures or letters associated by multiplication or division are considered as within brackets; other figures or letters connected to them by a plus or minus sign are treated as single entities. Briefly, multiplication and division take precedence over addition or subtraction.

Units are often not specified; if *f* is defined simply as "the focal length of the lens," are we to take the focal length in millimetres, as engraved on the mount, or do we have to convert it to inches first? The answer is that it does not matter, but the unit chosen must be kept to for all other lengths involved in the formula, and the final answer, if a length, will be in the same unit. Unless the formula is specifically designed for them, when we shall read "*f* is the focal length of the lens *in inches*," the use of mixed units will always lead to wrong answers.

Alkali. Strictly, a soluble hydroxide. The name is also applied to salts which give rise, in solution, to a preponderance of hydroxyl over hydrogen ions. Alkalies turn litmus paper blue which has been reddened by an acid. They precipitate certain metals from solution as oxides or hydroxides. Their chief characteristic, however, is their readiness to react with acids to form salts. The mineral alkalies are the hydroxides of potassium and sodium, KOH and NaOH, also the hydroxides of certain rarer metals, notably lithium. Ammonia NH_3, hydrazine N_2H_4 and some other organic substances, are powerful alkalies. Solutions of such salts as borax and the alkaline carbonates show alkaline properties owing to hydrolysis. (See ACIDS, ACIDITY, and *p*H VALUE.)

Alkaline Development. See DEVELOPMENT.

Alpine Photography. This phase of camera-work is now regularly practised by the great number of tourists who visit the Alpine regions every year, and the climbers who carry cameras will find that special conditions may govern their exposures. An exposure meter should be carried and used in any case, and an essential for rendering good Alpine or mountain scenery is undoubtedly a camera to which a long-focus lens may readily be adapted. This will be found absolutely necessary if any foreground is to be shown with distant mountains behind. If the ordinary short-focus lens is used, the distant peaks will appear miserably small; but,

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by retreating a little farther away from the bridge, hut, pine-tree, or whatever else constitutes the foreground, and using the long-focus lens, the background of hills will be shown in very much truer proportions. The human eye is not a wide-angle instrument. The second thing essential is lightness. Miniature cameras have their advantage here. On a long day's climb every additional ounce will tell its tale.

As regards exposure, the great thing is not to over-expose above the snow-line, nor to under-expose beneath it. The exposure required at an altitude of 10,000 ft. for mountains perhaps ten miles away is so extremely rapid, that it is apt to lead one to forget that down in the valleys, amid dark châlets and pine forests, very different conditions prevail. Panchromatic films or plates, well backed, should be used for nearly all alpine work, and a light colour-filter will be needed if the gradations in snow are to be rendered properly. To prevent slight loss of definition due to the ultra-violet light that is so prevalent at high altitudes, and for which lenses are in general not fully corrected, a U.V. (ultra-violet) filter should be carried, especially for miniature cameras. This provides correction enough for a deep blue sky; the yellow filter should be reserved for occasions when slight over-correction of the sky is permissible. Care should be taken not to over-develop negatives of alpine subjects.

Alum. Under this name a series of important double salts are classed. These salts are characterised as being double sulphates of monovalent and trivalent metals, crystallising in octahedra, and containing 24 molecules of water of crystallisation, and have therefore the common formula of $M_2'SO_4$, $M_2'''(SO_4)_3$, $24\,H_2O$. The principal alums are ammonia alum, chrome alum, potash alum and iron alum. *The term "alum", without qualification, always means potash alum.*

Ammonia Alum (Fr., *Alun Ammoniacal;* Ital., *Allume di Ammoniaca;* Ger., *Ammoniakalaun*). $(NH_4)_2SO_4Al_2(SO_4)_3$, $24H_2O = 906$. Solubility of crystals: 1 in 12 of water at 50° F., 1 in 0.5 of boiling water, 1 in 2 of alcohol.

Chrome Alum (Fr., *Alun de Chrome;* Ital., *Allume di Cromo;* Ger., *Chromalaun*). K_2SO_4, $Cr_2(SO_4)_3$, $24H_2O = 998$. A deep purple crystalline salt, solubility 22 in 100 of water at 77° F., insoluble in alcohol. Its solution is purple by reflected, and reddish by transmitted, light. It is commonly used to harden the emulsion of plates or films (but not papers) to prevent

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reticulation and frilling. It should not be dissolved in hot water. (See HARDENING STOP BATH.)

Potash Alum (Fr., *Alun ;* Ital., *Allume comune ;* Ger., *Alaun* or *Kalialaun*). $K_2SO_4Al_2(SO_4)_3,24H_2O=948$. Colourless crystals, used for rendering the films of gelatine less liable to mechanical injury, by hardening them, and also clears them from stains. Also used in the hypo-alum toning bath. (See TONING.) Solubility of crystals; 9·5 in 100 at 65° F., 280 in 100 of boiling water.

Iron Alum. (Fr. *Alun de fer ;* Ital. *Allume di ferro ;* Ger. *Eisenalaun*) $Fe_2(SO_4)_3(NH_4)_2SO_4\ 24\ H_2O=964$. Grey-mauve crystals forming a yellow solution. Solubility of crystals, 14 in 100 of water at 68° F.

Aluminium (Fr. and Ger., *Aluminium ;* Ital., *Alluminio*). Al=27. A silvery white metal, used for lens mounts and camera fittings on account of its lightness; its weight, bulk for bulk, being less than half that of the brass previously used. It has also been suggested as a means of precipitating silver from residues. It has been used as a substitute for magnesium in flashpowders, and the fine wire or foil used in flashbulbs is an alloy of aluminium with a little magnesium. (See FLASHLIGHT.) The " silver " screens used for projection are in fact coated, not with silver, but with very fine aluminium powder. (See PROJECTOR.)

Aluminium Sulphate (Fr., *Sulfate d'aluminium ;* Ital., *Solfato di alluminio ;* Ger., *Aluminiumsulfat*). $Al_2(SO_4)_3$, $18H_2O$. It has been suggested as a substitute for the ordinary and chrome alums, for hardening negatives and prints, and in emulsion-making.

Ambrotype. An American synonym for a collodion positive.

Amidol. 2–4 diaminophenol hydrochloride. $OH(C_6H_3)(NH_2.HCl)_2=197$. Synonyms, diaminophenol, dianol, dolmi. Developing agent of extremely high activity, Watkins factor 15, producing a normal developer by the addition of sulphite only. White or light grey crystalline needles, readily turning darker by oxidation, but will keep almost indefinitely in bottle with cork sealed in with wax. May be used, however, even if it has turned quite dark in storage. Soluble in 5 times its weight of water at room temperature, but is rather less soluble

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in solutions of sodium sulphite. Its solution oxidises so readily that the developing solution must be used within a few hours of being made up, but it can be stabilized a little by adding a trace of metol or hydroquinone. Amidol gives very little fog, and has been recommended for tropical development. It is the only common developing agent that will develop in acid solution, and it will also develop in the presence of hypo, making a combined developer and fixer. Gives pure black image, and is used chiefly for bromide paper. It has the disadvantage of staining fingers and finger-nails an intense brown. Does not readily stain prints, but when it does the stains are blue-brown. (See DEVELOPMENT and BROMIDE PAPER.)

Ammonia (Fr., *Ammoniaque ;* Ital., *Ammoniaca ;* Ger., *Wasseriges Ammoniak, Salmiakgeist*). $NH_3=17$. An extremely volatile pungent gas, very soluble in water, with which it combines forming the strongly alkaline ammonium hydroxide NH_4OH. The saturated solution, known as *liquor ammoniæ fortissimus* or " 880 ammonia," has specific gravity 0·880 and contains about 308 gm. of NH_3 per litre. Concentrated solutions lose ammonia rapidly by evaporation, and absorb carbon dioxide, forming ammonium carbonate. Store, preferably at half above strength, in incompletely filled stoppered bottles in a cool place.

Ammonia was at one time widely used as accelerator in pyro developers. (See *Pyro-ammonia* under DEVELOPMENT.) In modern practice it is used occasionally in warm-tone developers, also in colour-film processing, for hypersensitising films, in hypo-eliminators, and in general when a mild or volatile alkali is wanted.

Ammonium Bichromate (Fr., *Bichromate d'ammoniaque ;* Ital., *Bicromato d'ammoniaca ;* Ger., *Dichromsaures Ammoniak*). $(NH_4)_2Cr_2O_7=252$. Often used in preference to the potassium salt in photo-mechanical printing, and for the gum-bichromate process. Six parts replace seven parts of potassium bichromate, with the advantage that a 10 per cent. solution does not crystallize out in cold weather. (See also CARBON and OIL PROCESSES.)

Ammonium Bromide (Fr., *Bromure d'ammonium ;* Ital., *Bromuro d'ammonio ;* Ger., *Bromammonium*). $NH_4Br=98$. Its chief use is as a restrainer (*q.v.*), particularly in the production of warm tones by development, but it is sometimes used in the preparation of gelatino-bromide emulsion. Should

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not be used in alkaline developers as a substitute for potassium bromide, owing to liberation of ammonia. Solubility: 1 in 1 of cold water, 1 in 13 of alcohol.

Ammonium Carbonate (Fr., *Carbonate d'ammoniaque;* Ital., *Carbonato d'ammoniaca;* Ger., *Ammoniumcarbonat, Kohlensaures Ammoniak*). A mixture of ammonium bicarbonate $(NH_4)HCO_3$ and ammonium carbamate $NH_2CO_2NH_4$ in equimolecular proportions. M.W. = 157. White waxy lumps or cubes, smelling of ammonia and developing a crust of bicarbonate on exposure to air. For photographic use, buy "resublimed cubes," and scrape away all powder before weighing. Decomposed by heat; all solutions must be prepared with cold water. Used as alkali in warm-tone developers for slides, and sometimes also for papers. Solubility: over 40 per cent.

Ammonium Chloride (Fr., *Chlorure d'ammonium;* Ital., *Cloridrato d'ammoniaca;* Ger., *Chlorammonium, Salmiak*). $NH_4Cl = 53{\cdot}5$. Synonyms; Muriate of Ammonia, Hydrochlorate of Ammonia, Sal-ammoniac. It is principally used as an addition to a fixing-bath, to accelerate fixation. (See RAPID PROCESSING.). And in selenium toners. (See TONING.) Solubility: 1 in 3 of cold water, 1 in 55 of alcohol.

Ammonium Hydroxide. See AMMONIA.

Ammonium Iodide (Fr., *Iodure d'ammonium;* Ital., *Ioduro d'ammonio;* Ger., *Iodammonium*). $NH_4I = 145$. Used for making iodised collodion. Solubility: over 4 in 3 of water, 1 in 4 of alcohol, 1 in 20 of ether, and 1 in 20 of alcohol and ether.

Ammonium Oxalate (Fr. *Oxalate d'ammonium;* Ital., *Ossalato di ammoniaca;* Ger., *Ammoniumoxalat.*) $(NH_4)_2C_2O_4 = 124$. Sometimes used for preparing paper for platinotype printing. Solubility: 1 in 22 of cold water; insoluble in alcohol.

Ammonium Persulphate (Fr., *Persulfate d'ammoniaque;* Ger., *Ueberschwefelsaures Ammonium*). $(NH_4)_2S_2O_8 = 228$. Decomposes in hot water or on exposure to moist air. Dry salt keeps well; solutions decompose in a few days. Solubility: 1 in 2 of water. Used in photography principally as a reducer. (See REDUCTION.)

Ammonium Sulphide (Fr., *Sulfure d'ammoniaque;* Ital., *Solfuro d'ammoniaca;* Ger., *Ammoniumsulfid*, or, *Schwefelammonium*). $(NH_4)_2S = 68$. Synonym: Sulphuret of ammonia. Prepared by passing sulphuretted hydrogen through

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ammonia solution until the gas ceases to be absorbed. It can be used in the sulphide toning process (*q.v.*), and is also used in intensification (*q.v.*) to darken the white image obtained by bleaching the negative with mercuric chloride. A caution is necessary as to the use and storage of this in any room where sensitive materials of any kind are kept, as the vapours may act on the sensitive surface. If an amount of ammonia equal to that originally used is added after saturation with sulphuretted hydrogen, ammonium hydrosulphide is formed ; this is often preferred.

Ammonium Thiocyanate (Fr., *Sulfocyanure d'ammonium ;* Ital., *Rodanuro*, or, *Solfocianuro d'ammonio ;* Ger., *Rhodanammonium*). Synonym : Ammonium sulphocyanide. $NH_4CNS = 76$. Used in toning gelatino-chloride printing-out papers, and has also been recommended as a fixing agent instead of hypo. It is a very deliquescent salt, soluble also in alcohol. (See TONING.)

Ammonium Thiosulphate $(NH_4)_2S_2O_3 = 148$. Used for fixing as an alternative to sodium thiosulphate, the advantage being that the ammonium salt fixes three to four times as rapidly. It is also more soluble, and can be kept as a 60 per cent. solution. (Solubility: 60 per cent. at 10° C., 70 per cent. at 60° C.) If fixing and washing are thorough, the use of the ammonium salt involves no loss of permanence, but if either is scamped brown stains will appear sooner than if the sodium salt had been used.

Ammonium thiosulphate is the active agent in the commercially prepared rapid fixing salts; a standard formula, due to Allnut, is as follows:—

Ammonium thiosulphate .	4 oz.	(200 gm.)
Sodium sulphite, anhydr. .	130 gr.	(15 gm.)
Acetic acid (glacial) . .	140 min.	(15 c.c.
Boric acid . . .	65 gr.	(7·5 gm.)
Potash alum . . .	22 gr.	(2·5 gm.)
Water to	20 oz.	(1000 c.c. .

It should be noted that an acid ammonium thiosulphate solution can attack the silver image if the film or print is left in it too long, especially if the fixer is a little *too* acid. Warm-tone papers, owing to the fine grain of the image, are the most likely materials to be affected.

Amphitype (*ἀμφί*, on both sides, and *τύπος*, an impression, as of a seal). A curious process which was invented by Sir

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John Herschel, who thus describes his method of procedure :—

" Paper proper for producing an amphitype picture may be prepared either with the ferro-tartrate or the ferro-citrate of the protoxide or the peroxide of mercury, or of the protoxide of lead, by using creams of these salts, or by successive application of the nitrates of the respective oxides, singly or in mixture, to the paper alternating with solutions of the ammonio-tartrate or ammonio-citrate of iron ; the latter solution being last applied, and in more or less excess. Paper so prepared and dried takes a negative picture in time varying from half-an-hour to five or six hours, according to the intensity of the light ; and the impression produced varies in apparent force, from a faint and hardly perceptible picture to one of the highest conceivable fulness and richness both of tint and detail, the colour in this case being a superb velvety brown. This extreme richness of effect is not produced except lead be present, either in the ingredients used or in the paper itself. It is not, as originally supposed, due to the presence of free tartaric acid. The pictures in this state are not permanent. They fade in the dark, though with very different degrees of rapidity, some (especially if free tartaric or citric acid be present) in a few days ; while others remain for weeks unimpaired, and require whole years for their total obliteration. But though entirely faded out in appearance, the picture is only rendered dormant, and may be restored, changing its character from negative to positive, and its colour from brown to black (in the shadow), by the following process :— A bath being prepared by pouring a small quantity of solution of pernitrate of mercury into a large quantity of water, and letting the subnitrated precipitate subside, the picture must be immersed in it (carefully and repeatedly clearing off the air-bubbles), and allowed to remain till the picture (if anywhere visible) is entirely destroyed, or, if faded, till it is judged sufficient from previous experience ; a term which is often marked by the appearance of a feeble positive picture of a bright yellow hue on the pale yellow ground of the paper. A long time (several weeks) is often required for this, but heat accelerates the action, and it is often complete in a few hours. In this state the picture is to be very thoroughly rinsed and soaked in pure warm water, and then dried. It is then to be well ironed with a smooth iron, heated so as barely not to injure the paper, placing it, for better security against scorching, between smooth clean papers. If, then, the process has been successful, a perfectly black positive picture is at

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once developed. At first it most commonly happens that the whole picture is sooty or dingy to such a degree that it is condemned as spoiled, but on keeping it between the leaves of a book, especially in a moist atmosphere, by extremely slow degrees this dinginess disappears; and the picture disengages itself with continually increasing sharpness and clearness, and acquires the exact effect of copperplate engraving on a paper more or less tinted with pale yellow."

Anaglyph; Anaglyphoscope (*ἀνά*, in the sense of back; *γλύφω*, I carve). A means of producing stereoscopic effects due to MM. Louis Ducos du Hauron and D'Almeida. One picture of the stereoscopic pair is printed in red and the other in a greenish-blue—at any rate, the tints must be nearly complementary. As both impressions are superimposed on the same white paper, and the two unlike pictures cannot exactly coincide, a somewhat confused double image results. If this anaglyph be viewed by the anaglyphoscope—a pair of spectacles, one glass of which is green and the other red—each eye sees only one element of the two coloured stereograms, and a stereoscopic effect is produced.

The principle of the anaglyph is applicable to stereoscopic projection with the optical lantern. According to one method the two pictures of the stereographic transparency are projected upon the same screen by means of two lanterns, but in the optical path of each lantern there is interposed a coloured glass, the two colours being complementary to each other; the double and confused image on the screen being viewed by an anaglyphoscope, having glasses of corresponding colour, the stereoscopic effect is obtained. Anaglyphs have been produced from time to time as illustrations of topical events in weekly journals and also used with striking success for the projection of shadows of figures in motion on a stage screen, the shadows being cast by two adjacent spotlights, one red and the other green, placed at the back of the stage.

Instead of using complementary colours, the properties of polarized light may be used to present one picture of the stereoscopic pair to one eye and one to the other. Various methods of doing this have been suggested, but the "Vectograph" appears to be nearest to realization on a commercial scale. In this method, one image is printed on each side of a film on a special polarizing base, which has the property that the light on one side is polarized in one direction, while on the other side it is polarized in a second direction at right angles

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to the first. The film is then backed with a metallized sheet, and viewed through spectacles the "lenses" of which are analyzers with their axes at right angles. Thus each picture is only seen by one eye, and the required stereoscopic effect is produced.

For stereoscopic projection exactly the same principle is applied, the two pictures of the stereo pair being projected on top of one another on the same screen either from two independent projectors or by means of a "beamsplitter" (*q.v.*) from a single projector with one lens. A polarizing screen is interposed in the optical path of each picture, the axes of polarization being at right angles, and polarizing spectacles correspondingly set are used to view the pictures. A metallized ("silver") screen must be used; others depolarize the light. The well-known "3D" cine pictures are produced in this way. The great advantage over the more primitive two-colour anaglyphic method is that, polarizers and spectacles being colourless or nearly so, pictures in full colour may be projected.

See also STEREOSCOPIC PHOTOGRAPHY.

Anamorphote Lens. A lens which contains a cylindrical element, and consequently distorts like a cylindrical mirror. These lenses are mainly used in wide-screen cinematography. If a photograph is taken through a lens with the axis of its cylindrical components vertical, the scale of the image is less in a horizontal direction than in a vertical direction, so that the image is horizontally compressed. People appear unnaturally tall and thin, but as the image still occupies the full width of the normal image-space, it covers a wider horizontal area of the subject than would a normal lens, so that when expanded back to normal proportions by projection through a second anamorphote lens a wide-screen picture is obtained. Anamorphote attachments can also be had for use in front of a normal lens, and these are more likely to be used by amateurs, partly because the attachment can be used or not as desired, and partly because it can be transferred from camera to projector as required. Larger models of such an attachment can also be used in still photography, the re-expansion of the compressed image here being done in enlarging.

Anastigmat ; Anastigmatic (*ἀνά*, in the sense of back, and *στιγμή*, a dot or a mathematical point). A lens should be said to be anastigmatic—or simply stigmatic—when it refers

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every point on the scene accurately to a corresponding point on the plate ; but in practice the terms are used as signifying freedom from that aberration called astigmatism. (See ASTIGMATISM and LENS.)

Angle of View, or View Angle. It is sometimes desired to know the angle of view included by a lens when used on a plate of given size. There exist two conventions with regard to the angle of view, some basing it on the diagonal of the plate and some on the longer side. So long as no confusion arises, it is immaterial which convention is adopted. The angle in either case can be found by dividing the longer side (or diagonal) by the focal length of the lens and referring to the following table :—

SORET'S TABLES OF ANGLES INCLUDED BY A LENS

Ratio, diagonal to focal length.	Angle included by lens.	Ratio, diagonal to focal length.	Angle included by lens.
2·67	106° 16′	1·125	58° 42′
2·5	102° 43′	1·10	57° 37′
2·33	98° 50′	1·00	53° 6′
2·25	96° 44′	0·9	48° 27′
2·0	90°	0·875	47° 15′
1·75	82° 22′	0·86	46° 24′
1·67	80° 33′	0·83	46° 11′
1·5	72° 44′	0·80	44° 23′
1·33	67° 31′	0·75	41° 7′
1·25	64°	0·67	36° 52′
1·20	61° 55′	0·5	28° 4′
1·17	60° 30′	0·33	18° 36′
1·14	59° 28′	0·25	14° 20′

Example :—What angle is included by a 10-in. lens on a plate the diagonal of which is 12 in. ? 12÷10=1·20, and against this we find 61° 55′.

When comparing the angles of view of two cameras making negatives of different shapes, neither the longer side nor the diagonal is a very satisfactory basis of comparison. In such cases the diagonal of a square having the same area as the negative should be taken. This can be found by taking the square root of twice the area of each negative. The following table gives (*a*) the actual diagonal, and (*b*) diagonal of equivalent square, for the most usual negative sizes.

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Negative	*Diagonal*	*Diag-equiv-square*
24 × 24 mm.	34 mm.	34 mm.
24 × 36 mm.	43·4 mm.	41·5 mm.
28 × 40 mm.	49 mm.	47·4 mm.
3 × 4 cm.	50 mm.	49 mm.
4·5 × 6 cm.	7·5 cm.	7·35 cm.
4 × 6·5 cm.	7·6 cm.	7·22 cm.
6 × 6 cm.	8·5 cm.	8·5 cm.
2¼ × 2¼ in.	3·2 in.	3·2 in.
2¼ × 3¼ in.	3·96 in.	3·83 in.
2½ × 3½ in.	4·31 in.	4·18 in.
3¼ × 4¼ in.	5·35 in.	5·25 in.
9 × 12 cm.	15 cm.	14·7 cm.
4 × 5 in.	6·4 in.	6·33 in.
3½ × 5½ in.	6·5 in.	6·2 in.
4¾ × 6½ in.	8·05 in.	7·85 in.
6½ × 8½ in.	10·7 in.	10·5 in.

Example:—Which includes the wider angle of view, a 4 × 6·5 cm. camera with 7·5 cm. lens or a ¼-plate camera with 5½-in. lens? Taking the third column, and dividing by focal length in each case, we find $7{\cdot}22 \div 7{\cdot}5 = 0{\cdot}962$ for the V.P. camera, and $5{\cdot}25 \div 5\frac{1}{2} = 0{\cdot}955$ for the ¼-plate camera. The former therefore includes the wider angle of view. (See Soret's table above.)

It should be noticed that a lens having a focal length approximately the same as the diagonal (or diagonal of equivalent square) of the negative is considered a lens of "normal" focal length for the size of negative in question. Lenses of shorter focal length are said to include a "wide angle," or are called "wide-angle lenses," while those of longer focal length are "narrow angle," "long-focus," or possibly "telephoto."

The angle of view may also be determined by a simple geometrical method.

Draw a straight line A B equal in length to the longer side or diagonal of the negative, bisect this at C, from C draw a perpendicular D C equal to the focal length of the lens, connect A D, D B, then the angle included by the lens is equal to the angle A D B, which may be measured by laying a protractor on it and reading off the degrees included. The complete figure is shown on page 28.

(See also Wide Angle, Perspective, Distortion, Focal Length, and Lens.)

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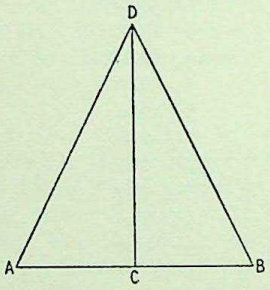

Angström Unit. A ten-millionth of a millimetre. The recognised standard of measurement in speaking of wavelengths of light. Thus a green line in the spectrum whose wavelength was 5,500 ten-millionths of a millimetre in length would be designated by 5,500 A.U. Often this is abbreviated to 5,500 A, and it is also usual to give wavelengths in millimicrons ($m\mu$). 1 $m\mu = 10$ A, so that the wavelength mentioned would be 550 $m\mu$.

Anhydrous means free from water, as in the terms anhydrous alcohol, or anhydrous ether. An anhydrous salt is one that contains no water of crystallisation. (See EQUIVALENCE, CHEMICAL.)

Aniline Process. In 1865 Willis patented this process which consists of impregnating paper with ammonium bichromate and phosphoric acid, drying, and then exposing under a positive to the action of light, and subjecting it to the vapour of aniline, by which means an image in aniline colours was formed. H. W. Vogel suggested the following method of procedure :—

Sensitising Solution.

Potassium bichromate	1 part.
Phosphoric acid, Sp. Gr. 1·124 . .	10 parts.
Water.	10 parts.

Good paper, such as Rives or Saxe, is allowed to float on this for one minute, and then quickly dried. It is then exposed under a negative or line drawing, and developed by placing in the bottom of a box, to the lid of which is affixed a sheet of blotting paper impregnated with commercial aniline 1 part, benzine 16 parts. The image appears fairly quickly (in a few

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minutes), and of a greenish-blue black, which turns to blue when the prints are soaked in water. If the fuming is carried on for some time the tones become blacker.

(For other processes in which coal-tar colours are used, see ANTHOTYPE, DIAZOTYPE, and FEER-TYPE.)

Animal Photography. See NATURE and ZOO PHOTOGRAPHY.

Anthotype (*ἄνθος*, a flower). An old process yielding exceedingly fugitive prints, depending for its principle upon the bleaching action of light upon chlorophyll and other vegetable colouring matters, when these are spread upon paper and exposed under a negative. More recently Messrs. A. and L. Lumière have suggested reproducing a coloured transparency by exposing under it a sheet of paper prepared with a mixture of fugitive colours, as for example quinoline blue, curcuma, and a rapidly fading red. The "Utocolor" colour printing paper was based on this procedure, but attempts to fix such images have been unsatisfactory, as metallic bases which will unite with the colouring substances alter the tint.

Anthrakotype (*ἄνθρακος* genitive of *ἄνθραξ*,, charcoal or coal). A process for reproducing in carbon or pigment such subjects as show little or no half-tone. Paper is coated with plain gelatine, say 1 to 8 or 10 of water, and when dry is sensitised in a bichromate bath—say 1 part of potassium bichromate in 20 of water. The paper is now exposed under a positive, soaked in water, blotted off, and then dusted over with the pigment, which adheres to those parts where the gelatine was protected from light, and is consequently swelled by the water. Careful sponging now removes all excess of pigment. Tracings may be reproduced with remarkable perfection by the anthrakotype process.

Antihalation; Antihalo. See BACKED PLATES and HALATION.

Antinous Release. Trade name of the wire release (for shutters) introduced by W. Watson and Sons, to whom this invention is due. (See SHUTTER RELEASES.)

Antiseptics. Substances destructive to bacilli and microscopic fungi. Used in photography to prevent putrefactive change or the growth of fungus in gelatinous or starchy mixtures. Phenol (carbolic acid) and salicylic acid are frequently used in gelatine, and oil of wintergreen in mountants.

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Alcohol, if present to the extent of about 20 per cent., prevents the putrefaction of most organic mixtures. Formalin is also often employed.

Aphengoscope. Early name for EPISCOPE, *q.v.*

Aplanat. One of the many names given to a rapid rectilinear (R.R.) lens. (See LENS.)

Aplanatic (*ἀ*, negative particle, and *πλανάω*, I lead astray). A term applied to a lens to denote that spherical and chromatic aberration have been eliminated so far as is practicable; it is impossible to do it completely. Practically it means that a lens will give reasonably sharp definition with its full aperture. (See LENS.)

Apochromat. Lens especially highly corrected for chromatic aberration. Usually a lens for special process work (block-making) rather than for general photography.

Apron. Band of celluloid or other material used to separate successive turns of film when rolled up for development in a tank. (See DEVELOPMENT.)

Aqua Fortis. See NITRIC ACID.

Aqua Regia. (Fr., *Eau régale*; Ger., *Königswasser.*) Synonym: Nitro-hydrochloric acid. A mixture of 3 parts of hydrochloric acid with 1 part of nitric acid. It is used to dissolve gold for the preparation of gold (auric) chloride, the active agent being nascent chlorine.

Aquatint. See GUM BICHROMATE.

Aquatint, Photo. See *Intaglio Process* in PHOTO-MECHANICAL PRINTING PROCESSES.

Arabic Gum. See GUM ARABIC.

Arabin Process. See GUM BICHROMATE.

Architectural Photography. The ideal camera for architectural photography is one that will take a selection of lenses of different focal lengths, including wide-angle lenses, and in which the subject can be seen, focused, and arranged on a ground-glass screen. A rising front that will allow the lens to be raised as high as the top edge of the plate is very desirable, and this should be supplemented by a swing movement to front or back. A well-made stand camera is by far the best. The use of a wide-angle lens should not restrict

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the working of the rising front; this is more necessary with wide-angle than with narrow-angle lenses.

When the range of rising and falling in the camera front is insufficient for the work in hand the camera must be tilted, in order to get the subject on the plate as desired. This is no objection, provided that the camera has a swing back, but it involves considerably more trouble than the use of a front with a full range of rising movement. When the camera has been tilted to the desired extent, the back must be adjusted until it is vertical. If this is not done the upright lines of the building will not be true, but will converge like the outlines of a pyramid. (See DISTORTION.) A small spirit level and plumb line are extremely useful accessories in architectural photography to secure the correct vertical result.

A tripod that can be easily adjusted to any height is practically a necessity. When working in difficult places it frequently happens that the camera can only be levelled by adjusting the legs of the tripod independently. When setting the camera on a smooth surface, such as a floor, the less the legs are spread out the less will be the risk of slipping. On rough ground the case is reversed. For smooth floors or interior work generally there is no precaution against slipping that is so practical and efficient as the following simple arrangement. It consists of three light bars of hardwood, about 30 in. long, 1½ in. wide, and ¼ in. thick, connected at one end by a bolt passing through them, provided with a nut that may be tightened to grip the three bars together firmly when required. Near the free end of each bar there are three or four holes cut partially through, forming sharp indentations, The point of the tripod is placed in any one of these indentations, and there is not the slightest risk of slipping. The three bars may be turned from the centre to any angle, and so provide all necessary opportunity for adjusting the tripod and levelling the camera. When it is not in use the support may be closed by turning the three bars on the connecting screw until they form a flat piece, which can be carried with the tripod without any appreciable increase in weight or bulk.

A large proportion of architectural subjects have to be photographed in confined spaces. For this reason lenses of shorter focus than those most frequently used for landscapes will be necessary. A lens that includes an excessively wide angle on the plate for which it is used should be avoided, and care should be taken not to include a greater angle than is really necessary. A very good relation of focus to plate for

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general work is that of a lens having a focus a little less than the longer side of the plate—about 6 in. or 5¾ in. for half-plate. But a lens capable of covering a much larger area than the plate in use should be selected. Many subjects require that the lens should be raised considerably above the centre of the plate, and in such cases an extensive covering capacity is rendered necessary.

Whatever plates or film may be used, it must be remembered that halation will occur round windows and other brilliant parts of an interior subject unless precautions are taken. The plate-user must use backed plates as a matter of course. Windows should be avoided as far as possible, on account of their irritating brilliancy in the finished picture; but when it becomes necessary to include them, no fear need be felt that halation will spoil the result. (See BACKED PLATES and HALATION.)

Exposures are always difficult to estimate in indoor work. If there is light enough to operate a photo-electric meter, no difficulty need arise. In cases where the light is too weak to move the pointer it is often satisfactory to point the meter at the source of light (window, etc.) from the position of the subject, and work out the exposure in the ordinary way from the meter reading. Multiplying the exposure by twenty for light objects, or by fifty or more for dark objects, will give a close approximation to the exposure required.

At the time of writing, exposure meters based on the use of a photosensitive conductor (cadmium sulphide) are expected to make their appearance very shortly. These have at least a hundred times the sensitivity to weak light of the photo-electric cell type of instrument, and in consequence should be really invaluable for poorly lit architectural interiors.

Extinction meters, especially in fairly practised hands, are extremely valuable for indoor work, as the increased sensitivity of the eye that occurs in a poor light extends their range considerably. This increased sensitivity, however, has to be allowed for. For a medium-fast plate or film (about 50 A.S.A.) the following suggested exposures may be useful as a rough guide for a beginner. Stop assumed, *f*/11.

Nave	5 sec. to 15 sec.
Aisles, white glass	5 sec. to 20 sec.
Aisles, stained glass	40 sec. to 2 min.
Choir	30 sec. to 3 min.
Crypt	1 min. to 10 min.
Cloisters	2 sec. to 10 sec.

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The following brief note of the characteristics of the various styles of English architecture may be useful:—*Norman* (1066–1100) : Round-topped door and window ways ; short heavy pillars and zigzag patterns. *Transition* (1100–1200) : As Norman, with introduction of pointed windows. In the later examples of this style—often called *Early English*—(to about 1280) the windows are narrower and the pillars are clustered. Still later (to about 1380) much tracery was introduced in the windows, this being the so-called *Decorated Period*. The *Perpendicular Period* (1380–1547) is characterised by prevailing upright lines in windows, doorways, and often square tops to windows. This developed into the *Tudor Style* (1550–1600), in which the square top is developed and carried out as a leading ornamental idea in other ways. The *Jacobean Style* (1603–1650) is very mixed ; but with a considerable infusion of classical.

Architectural details, if in places not easily accessible, are often best photographed by means of a telephoto lens (*q.v.*).

A.R.P.S. Associate of the Royal Photographic Society (*q.v.*).

Arrowroot (Fr. and Ital., *Arrowroot ;* Ger., *Pfeilwurzelmehl*). The starch obtained from the tubers of Maranta Arundinacea. It is a fine, white, tasteless, odourless powder which has a peculiar crepitating feel in bulk. It is used for sizing papers and as the vehicle for sensitive iron salts in printing papers ; also employed in making a paste for mounting photographs.

Art Terms. Many of the words and phrases used in reference to certain forms of graphic art can be applied to photographic work equally well ; others are used with some difference of meaning ; while others, again, are more or less inappropriate. Following are brief suggestions on the significance of some of the terms in common use.

Accent or *Accentuation*. Emphasis laid on some portion of the subject so that it attracts special attention. The accented object may be relatively small in size, and the emphasis is generally obtained by extra depth of tone or by brilliance of lighting.

Atmosphere. The tones of the subject are such as to convey the impression of air, space and distance. (See AERIAL PERSPECTIVE.)

Background. Planes beyond the principal subject, especially in portraits and still-life. The background should be sufficiently

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unobtrusive not to compete in interest with the main subject, to which it should be subordinated.

Balance. An arrangement which prevents the picture from appearing lop-sided, topheavy and so on. A strong mass towards one side generally demands a secondary mass towards the other.

Breadth. Treatment which presents the subject in masses and tones so that minor features and details are suppressed rather than emphasised.

Chiaroscuro. A combination of the Italian words for light and dark. The distribution of the bright and dark tones in a picture. Patches of equal brilliance or of similar depth scattered over the picture space create a spotty and restless effect.

Composition. Selection and arrangement of the subject to secure the qualities generally required in a picture—balance, harmony and so on. (See PICTORIAL COMPOSITION.) The term *construction* is used with a similar meaning.

Contrast. Inclusion and arrangement of features of opposite or different character to lend variety and avoid monotony. Contrasts may be those of light and shade ; of straight and curved lines ; of masses and lines giving vertical, horizontal and oblique directions ; of smooth and rough surfaces ; and so forth.

Detail. The smaller and less significant features of a subject. The fidelity of their rendering may be important or not ; it may not be necessary to show the individual leaves and twigs of trees in a landscape, while every detail might be required in a realistic rendering of a flower.

Flat. Applied to a tone it means uniform, without gradation ; applied to a photograph as a whole it suggests that the tone values are monotonous, and lacking sufficient contrast of light and shade.

Foreground. That part of the subject nearest the spectator. It may or may not be the most important feature. When it is, full detail and strength are required ; when it is not, it should be subdued and unobtrusive so as not to compete with more important features beyond.

Genre. Applied in a general way to figure subjects of a somewhat homely kind, and often suggesting some ordinary incident of everyday life. Simplicity of treatment is a usual feature.

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Gradation. The passing of tones or tints from dark to light. Such change may be gradual or rapid.

Group. Two or more figures or objects arranged to combine into a single subject.

Half-tones. Range of tones or shades lying between the deeper shadows and the higher lights.

Impressionism. Originally applied to the rendering by an artist of a subject or effect as it appealed to him without particular attention to details. There is too much of the mental aspect about it to make the term very appropriate in photography.

Key. The range of tones employed. If they are generally light and delicate the key is *high ;* when they are mostly dark and heavy it is *low.* A tone is out of key when it is too light or too dark in relation to other tones.

Motif. Main or dominant idea which prompted choice and treatment of subject.

Plane. A flat surface. An infinite number can be imagined, and in a landscape, for example, they may be roughly divided into three groups in which lie foreground, middle distance and distance respectively.

Proportion. Generally applied to the relative sizes of the constituent parts of a subject. Anything is said to be out of proportion when it appears to be too large or too small for its position and surroundings.

Silhouette. Rendering of objects as masses of dark tone with clearly defined outlines.

Style. The characteristic ideas and technique which are associated with individuals or with methods of treatment. A high-key print represents a particular style ; a photographer whose work is more or less easily identifiable has a style of his own.

Symmetry. Balance of form ; sometimes an exact repetition of form. In decorative design it plays an important part, but in other forms of work exact symmetry may be detrimental, making the result too formal. An example is a view straight down the aisle of a church, so that one vertical half of the print is almost an exact repetition of the other.

Texture. As regards the subject matter this refers to the characteristic rendering of surfaces and forms, fur, feature, skin, grass, snow, etc. Poor definition is often inimical to perfect rendering of texture.

Tone. The different degrees of light and shade in a photograph are called tones. They have to suggest the relative

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visual brightnesses of the subject depending on variations of light and colour. Any chemical process for altering the colour of the photographic image is called toning, so that the word *tone* is also used for the *colour* of the print. Tones, in the sense of colours, are called *warm* if they tend towards red, and *cold* if they tend to pure black.

Artificial Light, Photography by. Artificial light work falls naturally into two types; one where photographs are to be taken by whatever artificial light happens to be available, as in theatre work, night photography in the streets, and the like, and the other where the provision of the lights and their disposition is under the control of the photographer. The latter condition applies chiefly to portraiture and flash-light work (*q.v.*); the present article deals therefore with "available light" photography.

The choice of sensitive material and development technique for this work is important. Some use the fastest available films (400 to 1,600 A.S.A.) and develop normally in an ordinary developer; others prefer a slower and more fine-grained film, and either develop normally in a "super-speed" developer that increases speed by some fifty to one hundred per cent or alternatively rely on forced development ("development to finality"). Some, to obtain the utmost sensitivity, use forced development with a top-speed film. Each worker has to evolve his own technique by experience, but for his first trials the beginner should avoid all forms of forced development, for in this technique development times and exposure are closely inter-related. In the suggestions that follow, the use of forced development is not envisaged.

Theatre and Circus Photography. For this, as for other artificial light snapshot work, the miniature camera is the most useful equipment owing to the very fast lenses available for the small camera. With an *f*/2·8 lens and a fast panchromatic film (400 A.S.A. or over) exposures up to $\frac{1}{500}$ sec. are possible in a really brilliantly lit music-hall or at the circus, but in general the exposure needed is nearer $\frac{1}{50}$ to $\frac{1}{100}$ sec. A distinction has always to be drawn between the exposure needed to render the stage as a whole, and that needed for spotlit figures. The latter may only be a tenth of the former. A complete stage setting which includes spotlit figures is in consequence difficult to render satisfactorily, owing to the very wide range of contrast involved. Waterbath development (*q.v.*), or treatment in a two-bath developer (see FINE-

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GRAIN DEVELOPMENT) is of some assistance here. It should be noted that the average "straight" play is much less unevenly lit, but that at the same time the lighting is much less brilliant.

At any type of performance, a fast long-focus lens is invaluable, as the majority of seats are too far away to give good sized figures with the normal lens. Results are better with a long-focus lens and a seat not too near the front; in most theatres photography from the stalls involves too low a view-point.

Street Photography at Night. In the shopping centres of large towns, where shop lights assist the ordinary street lighting, slow snapshots ($\frac{1}{8}$ to $\frac{1}{50}$ sec.) can be taken at *f*/2 or *f*/2·8. An arcade, with lighted shop-windows on both sides of the figures, is a particularly good spot for night pictures. The portico of a cinema or theatre is often brilliantly lit, and makes another good setting for night work. Views of such entrances from across the road, with figures silhouetted against the lights, are also easy to take at $\frac{1}{250}$ to $\frac{1}{100}$ sec.

Away from the brightest lights, much longer exposures are needed. As a tripod will be required in any case, slower lenses are hardly less useful than the fastest. Exposures of from 1 to 20 sec. at *f*/3·5 may be tried, using the fastest material. Many delightful pictures await the night photographer, especially when wet streets provide reflections and a little mist is present to show up the rays of street lamps.

A lens-hood must be used to exclude all direct lights not actually included in the picture. A coated lens is particularly desirable in work of this type.

"Candid" Photography by Artificial Light. In an ordinary well-lighted room, or in a restaurant or other normally-lit public building, slow snapshots are possible in favourable circumstances. Pictures taken across the table at public dinners or other functions ($\frac{1}{10}$ to $\frac{1}{50}$ sec. at *f*/2 or *f*/2·8) are now common in newspapers, and similar exposures may be tried in any well-lit private room. An indication of the exposure required in any case where distances and power of lights is known, or can be estimated, is given in the exposure tables in the article on PORTRAITURE.

With the advent of high-speed colour film balanced for artificial light, pictures in colour can be taken in fairly bright "available light", as found at circus or music-hall performances, in a very well lit living-room, or in brightly lit shopping centres. With a speed of 125 A.S.A. or over, an *f*/2·8

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lens can often be used, but the greater reserves of an *f*/2 or even *f*/1·5 lens will prove exceedingly helpful, as the exposure needed is still about ten times that required for the fastest monochrome films.

(See also ELECTRIC LIGHT.)

For exposures with flashbulbs, see FLASHBULB.

Artigue's or **Fresson Process.** A method of carbon printing without transfer, invented by M. Artigue of Paris. Like the gum-bichromate process, it allows very complete control in development and the permanency of the results is assured.

The following method, due in the main to M. Duchochois, if carefully carried out, gives results very similar to those obtained upon M. Artigue's own "*Papier Velours.*" In 15 parts of water 5 parts of white and carefully picked gum arabic are dissolved—the round and slightly friable lumps being selected. When the solution is complete, a matter sometimes of days, the mucilage is strained through muslin, and we next add 100 parts of white of egg and a quantity of Indian ink or other finely ground water-colour sufficient to give a coating on paper, which shall be nearly full black or full coloured by reflected light, but not so opaque as altogether to obscure a coin behind the paper when both are held up to the window. Enough liquid ammonia to make the preparation slightly alkaline to test paper is now stirred in, but a minimum of two drops to each fluid ounce may be added in any case. The preparation is now ready for coating the paper, which should be done by brushing on a thin and uniform layer with a broad camel's-hair brush. (See GUM-BICHROMATE PROCESS.)

A fine paper, such as "Rives," should be used, and this should be coated with a film of plain gelatine before applying the pigmented mixture. The gelatinous mixture for use as a substratum may consist of:—

Hard gelatine	1 part.
Water	8 parts.

Soak, melt in water bath, strain through muslin into a warmed porcelain dish. The mixture must not be allowed to cool, and each sheet must be floated for an instant, and then be pinned up to dry. When dry it is coated with the Indian ink mixture in the way already described. The paper thus coated is insensitive to light, and must be sensitised by being floated, face upwards, on a solution of ammonium bichromate containing 1 part of the salt dissolved in from 10 to 20 parts of water. If the paper is soft and porous in texture the weaker

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solution should be used, and floating for a few seconds may be sufficient ; but if the paper is close in texture and is covered with a substratum of gelatine, the stronger sensitising liquid must be used, and the paper must remain floating on the bath for a longer period. The criterion is the penetration of the bichromate to the face of the paper, and when this is the case the pigmented film can be rubbed off by gentle friction with the finger. When the paper is dry it is exposed under the negative until details are visible at the back.

The development is an operation in which very widely different treatment may be necessary, according to atmospheric conditions and other circumstances which affect the solubility of the pigmented film ; but the instructions given for the development of the *non-transfer* pigment print, under GUM-BICHROMATE, may be taken as generally applicable. When the basis is smooth paper coated with gelatine, it becomes almost essential to adopt M. Artigue's expedient of developing with a soup-like mixture of ground sawdust and water.

The sawdust may be of any wood ; but it should either be ground in a roller-mill, or should be sifted, and only that used which will pass through a No. 12 (12 meshes to linear inch) sieve. The sawdust being mixed with water of the required temperature to the consistency of soup, this mixture is flushed and reflushed over the pigmented surface until development is complete—any increase in the temperature of the mixture being regulated by the considerations given above.

A.S.A. Speed. See SENSITOMETRY.

Asphalt Process or **Bitumen Process.** This process is the first by which a fixed photograph, in the ordinary sense of the term, was produced, and it is still employed in making photo-etched blocks and plates. Niepce, as early as 1827, produced a photograph of Kew Church on a metal plate coated with a bitumen varnish, and probably he employed oil of turpentine to wash away that bitumen which had not been rendered insoluble by the action of light. All bitumens and asphalts are more or less sensitive to light, light causing the material to become insoluble in the usual solvents ; and any bitumen or asphalt may be dissolved in benzol (from 1 of asphalt in 20 of benzol, to 1 of asphalt in 6 of benzol), and a metal plate having been coated, exposure is given under a negative if a relief block is wanted, or under a positive if an intaglio plate is required. A sufficient exposure having been

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given, the plate is developed by rocking in a dish containing rectified oil of turpentine, free from acid. If the plate is copper it may now be etched with a solution of ferric chloride (perchloride of iron), as explained under *Intaglio Process*, under PHOTO-MECHANICAL PRINTING PROCESSES. If the plate upon which the bitumen resist has been obtained is zinc, ferric chloride may still be used, but very dilute nitric acid is a more usual solution for etching zinc. An alternative method of working on zinc is to treat the zinc by the "lithographic" method, and print in the lithographic press.

Bitumen Process on Lithographic Stone. A lithographic stone, cleaned and prepared in the ordinary way, is coated with the sensitive bitumen varnish and, after exposure under a negative, the soluble bitumen is removed by washing with oil of turpentine, with the addition of ligroin as a restrainer if required. The stone, having been next washed by a vigorous stream of water, is dried, and treated by the usual lithographic method.

Half-tone or Process Blocks by the Bitumen Process. A copper or zinc plate is coated with bitumen, and it is exposed under a stippled negative of the kind mentioned in the article, PHOTO-MECHANICAL PRINTING PROCESSES. After development, or the removal of the superfluous bitumen, the plate is etched.

Aspherical. Term applied to a lens-surface ground to a curve other than part of a sphere. Such surfaces are difficult to grind with accuracy, and so are not used in camera lenses, but they are widely used in condensers for projectors.

Astigmatism. An aberration in lenses as a result of which a line running radially outward from the centre of the field of view cannot be sharply focused at the same time as a second line at right angles to the first. Astigmatism is greatest with lenses of wide aperture, and is progressively corrected by stopping down. Any lens substantially corrected for this fault is called an anastigmat. For a fuller discussion, see *Photographic Optics*, by Arthur Cox (Focal Press). See also LENS.

Astronomical Photography. Except for general views of the heavens, and for such work as the recording of meteors, the ordinary camera is unsuited to astronomical photography on account of the extreme smallness of the images. Even the sun or the moon give an image the diameter of which is only about a hundredth of the focal length of the lens used. It is therefore necessary to use some sort of telescope to obtain an

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image of useful size. The telescope may be used by the amateur in either of two ways. Those who expect to use a telescope frequently for photographic work should arrange a plate-holder that can be substituted for the eye-piece used for visual observation ; the image is then simply focused on the plate by the objective, or by the concave mirror of a reflecting telescope. Provided that the plate used is not orthochromatic or panchromatic, fair results can even be had by means of a simple spectacle lens of long focus, used at an aperture of *f*/50 to *f*/100.

Where it is desired to use an ordinary telescope in conjunction with a camera, the eye-piece is retained and the camera, complete with lens, is placed against it. If the eye is relaxed when focusing the telescope, and the camera is adjusted for distant objects, the image obtained will at least be reasonably sharp. It is greatly preferable, however, to put the final touches to focusing while observing the image on the ground-glass screen of the camera. A single-lens reflex is consequently a particularly convenient instrument to use for this work.

Large images, however obtained, entail long exposures, except when photographing the sun, and perhaps the moon; it then becomes necessary to swing the telescope, in some sort of equatorial mounting, to follow the apparent movement of the heavens. A sighting telescope, with cross-wires, is required for this ; if the main telescope is in use for photography, a small guide-telescope must be attached to it for this purpose. A spectacle lens of long focus and a cheap magnifier can readily be made up into a rough but usable instrument, cross-wires being provided by two strands of fine silk or very fine wire at the focus of the magnifier.

Photographing the Sun. The amount of light is here so plentiful that the eye-piece of the telescope may be used as a projecting lens, forming an image on a plate or film held some ten or twelve inches from the telescope. An old field-camera with shutter but no lens will serve as a light-tight connecting link. The image can usually be made large enough to show sun-spots without subsequent enlarging. A neutral filter should be interposed somewhere in the optical path to cut down light and heat ; even with the filter an exposure of 1/100th second or less will be sufficient.

Photographing the Moon. With a 100 A.S.A. film, placed at the focus of the object-glass of an average small telescope, which may work at about *f*/16, an exposure of about $\frac{1}{50}$th

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second will suffice when photographing the full moon. For a gibbous moon double this basic exposure, for a half-moon quadruple it, and for a crescent moon give eight times. If a larger image than that given by the object-glass alone is obtained by either of the above-mentioned alternative methods, the exposure should be increased in proportion to the area of the image. For exposures much in excess of ½ second, during which time the image will move by about 1/500th part of its diameter, the telescope must follow the moon.

Two lunar photographs taken at an interval of four weeks will show the moon in the same phase, but owing to the relative motions of moon and earth, the viewpoints will be slightly different. If prints from such a pair of negatives are mounted as a stereoscopic slide and viewed in a stereoscope, a marked effect of relief will be obtained, the moon presenting a very real spherical form. (See STEREOSCOPIC PHOTOGRAPHY.)

Planets and Stars. No matter what magnification is used, stars will register simply as points of light. The image can only be spread by prolonged exposure, and as the spreading is due to irradiation, it will still show no detail. The form of planets can only be shown by very high magnification, involving exposures running into many minutes and very accurate following of their apparent movement.

Comets and Meteors. As a comet is a comparatively slow-moving object, visible often for many nights in succession, it may be photographed in much the same manner as a planet. In photographing a faint comet, for which a long exposure may have to be given, it is best to follow the comet itself with the guide-telescope. The comet's movement against the stars will then be indicated by the direction and length of the short lines formed by the extension of the images of the stars.

For photographing meteors, which may appear at any instant and in any part of the sky, it is necessary to include a wide angle of view. For this work an ordinary camera is quite suitable. If on an equatorial mount, the stars will appear as points, while any meteors will appear as lines, the direction of which indicates the movement of the meteor. If, on the other hand, the camera is fixed, the star-images will be drawn out into the arcs of circles with a common centre at the Pole Star ; a meteor will then register as a line not parallel, except by accident, with those formed by the stars in its neighbourhood. By taking such photographs simultaneously from two points, the height of the meteor can be calculated.

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When meteoric showers are expected, the camera should be pointed towards their expected source; towards the constellation of Perseus for the August shower, or the Sickle in the constellation of Leo for the November shower.

Artificial Satellites. These, emitting no light of their own, can only be photographed when they are sunlit but seen against a dark sky. These conditions are met shortly before sunrise and shortly after sunset. Satellites are most simply photographed by a time exposure, with the camera stationary, using a long focus camera lens rather than a telescope. The stars then register as short lines; the satellite, owing to its own motion, as a long one.

Atmosphere in a Photograph. See AERIAL PERSPECTIVE.

Atmospheric Action. The free oxygen in the atmosphere will react with a good many photographic chemicals if these are carelessly stored. Developing agents in particular will take up oxygen, usually becoming dark in colour as they do so, and progressively losing their power to develop. Sodium sulphite will slowly oxidise to sulphate, which is useless as a preservative, and sodium sulphide will oxidise to a mixture containing thiosulphate (hypo) which will partially dissolve, instead of toning, any bleached image to which it is applied.

The air also contains some carbon dioxide; any hydroxide (*e.g.* caustic soda) will absorb this, its surface being converted into a crust of carbonate. Carbonate also forms on the surface of certain other chemicals, notably sodium sulphite, if too freely exposed to the air.

Atmospheric moisture is taken up by other chemicals; some get wet and eventually dissolve in the acquired moisture (*e.g.*, thiocyanates of potassium or ammonium). This process is called *deliquescence.* Other substances combine with the acquired water to form crystals; this is generally evidenced by caking. Certain compounds containing water of crystallisation (sodium sulphite and carbonate, for example) lose water to the atmosphere, so that the crystals crumble to a powder containing either the anhydrous salt or a lower hydrate. This is called *efflorescence.*

Traces of sulphur compounds, notably hydrogen sulphide, are usually present in the air, especially in towns; this gas is potent in bringing about the fading of prints, the image of which is partially converted to brown silver sulphide.

To protect them from air, all chemicals likely to be affected should be stored in tightly-corked bottles; if possible, the

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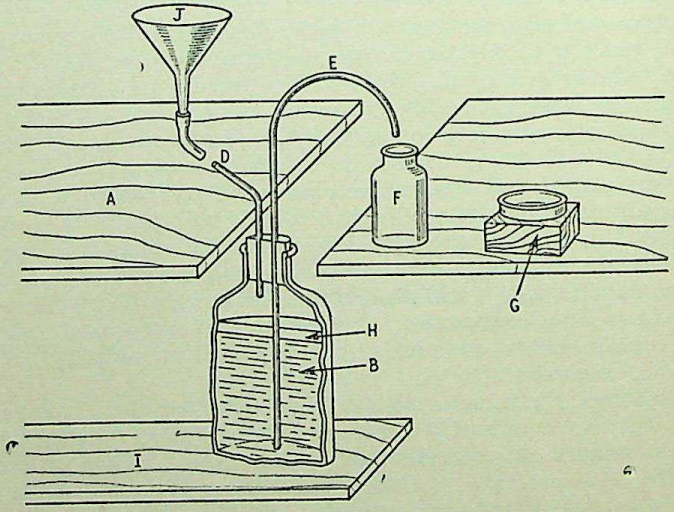
cork should be waxed in to render it air-tight. Tins, if they have really tight-fitting lids of the press-in type, are perfectly satisfactory for such substances as sodium carbonate and sulphite.

Mixed developers should always be kept in bottles filled to the neck and tightly corked, but where this is inconvenient a storage bottle like that shown below may be used, a layer of medicinal paraffin (H) being used to protect the solution from the air. Developer may be expelled from E by blowing through D, or E may be extended below the level of the bottom of the bottle to form a syphon. A glass tap, or a rubber tube with a pinch-cock, may then be used to draw off



developer. If the bottle is inset in the dark-room bench as suggested in the sketch, it may be refilled either through D, using the funnel J, or fresh supplies may be drawn from the beaker F through E by sucking out air at D. When not in use, E may be sealed by covering its end with a dilute solution of sulphite contained in F, the block G being used to raise F to the required level.

Atomic Theory, Calculations based on. See EQUIVALENCE, CHEMICAL; also WEIGHTS AND MEASURES.

Autochrome. See COLOUR PHOTOGRAPHY.

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Automatic Camera. At the time of writing, the term " automatic camera " is applied to those in which the adjustment of stop and shutter speed, or of stop if the shutter speed is fixed, is done, with no intervention from the photographer, by a built-in photo-electric exposure meter. In a semi-automatic camera, the adjustment of stop and/or speed is done by the user, though all he has to do is to turn stop or speed scale to bring a movable pointer up to the exposure-meter needle, or perhaps to bring the latter to a fixed mark. Such a camera is preferably described as having a " coupled exposure meter ".

Automatic Focusing. Refinement fitted to certain *de luxe* vertical enlargers, by which the projected image is kept continuously in focus as the head is raised or lowered to alter the scale of enlargement. (See ENLARGING.) The term has also sometimes been applied to a camera fitted with a coupled range finder. (See RANGE FINDER.)

Autotype Process. See CARBON PROCESS.

Available Light Photography. A rather ambiguous term for photography, without flash or other extra lighting, in conditions where the light is so poor that a need for flash might be expected. Indoor photography at night, in the home, restaurant, or theatre, would fall into this category. (See ARTIFICIAL LIGHT.)

Axis. Any straight line passing through the optical centre of a lens is termed an axis. That axis which passes through the centres of curvature of the various surfaces is termed the " principal axis " or " optical axis " ; any other is referred to as a " secondary axis."

Azol. See DEVELOPMENT.

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B

Backed Plates. A backed plate is one the back of which has been coated with some black or non-actinic substance to prevent halation (*q.v.*). The essentials of a backing material are that it should have the same index of refraction as the glass of the plate, that it should be in optical contact with the glass, and that it should absorb all light to which the plate is sensitive. If the first requirement is not satisfied, light will still be reflected from the back of the plate before entering the backing at all. It is usual to buy plates ready backed when halation is feared, but if in an emergency it is found that only unbacked plates are available, one of the following backing mixtures may be applied. They may also be used for backing lantern slides, in the making of which halation may occur if the negative shows strong contrasts of light and dark.

Mucilage	1 part
Caramel	1 part
Burnt sienna (powder)	1 part

Apply to the back of the plate with a roller squeegee or a pad of lint.

The following black backing is particularly suitable for panchromatic plates :—

Gelatine	50 gr. (11·5 gm.)
Glycerine	¼ oz. (25 gm.)
Water	1 oz. (100 c.c.)
Ivory black	30 gr. (7 gm.)

When applying a backing it is convenient to place the plate, glass outwards, in a printing frame, protecting the emulsion side with clean paper. The film side, and the edges, are thus

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kept free from backing. Alternatively, the backing mixture may be spread on paper and dried. When required for use, the backing is damped and pressed firmly into contact with the plate. The paper prevents the backing from rubbing or flaking off in the slide.

(See HALATION.)

Back Focus. Distance between the back surface of a lens and the image of an object at infinity. A knowledge of the back focus of a lens is valuable as indicating camera extension required. A telephoto lens (q.v.) is distinguished by having a back focus very considerably less than its equivalent focal length. (See also LENS and FOCAL LENGTH.)

Background. Anything used, as the name implies, as subordinate to or behind the principal figure or figures or objects in a photograph. If the figure or principal object is to stand out, the background should be as plain as possible, and of a tone distinctly higher or lower than the parts of the main subject which fall against it. Since the photographer's attention is naturally concentrated on the subject proper, background faults, such as a tree apparently growing from the subject's shoulder, are easily overlooked; such faults should be looked for, and eliminated by change of viewpoint, before the exposure is made. The sky can often be made to serve as background if a low viewpoint can be adopted.

For deliberate portraiture an artificial background is generally used; a plain distempered wall, a white or tinted blanket, or even a large sheet of brown or white paper without creases will serve very well. The background will print light or dark in the finished photograph according to the amount of light allowed to reach it, but note that if the depth of the background is to be controlled by lighting, there must be a fair space between it and the subject. For full-length figures, paper or cloth, hung from the picture rail and brought forward in a curve so that the subject actually stands on the background material, will conceal the ugly junction between floor and wall.

The following method of preparing a background and painting it will be found reliable. If the background is to be mounted on a rigid frame, this should be made first. Stout unbleached calico of the required size should be well wetted, and then laid over the frame, which should be placed flat on the floor. The canvas should be lightly nailed at the four

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corners, then, starting at one corner, nail down about six inches of it; then go to the other side of the frame and, stretching the calico as tight as possible, nail down six inches. Repeat this process, that is, working at alternate ends, till two are completely nailed down, then start the sides, working in the same way, and taking care to strain the cloth quite tight each time. If this is done, and it is kept well wetted, it will dry perfectly smooth and taut. A suitable paint is made with—

Powdered glue	4 oz.	(50 gm.)
Whiting	12 oz.	(150 gm.)
Treacle	6 oz.	(75 c.c.)
Water	80 oz.	(1000 c.c.)

This can be coloured with—

Ivory black	1 oz.	(12 gm.)
Ultramarine	½ oz.	(6 gm.)
Red ochre	½ oz.	(6 gm.)

Rub this down with a little glue first. This gives a medium neutral tint, and more or less will darken or lighten the colour. (See also PORTRAITURE.)

Back-Projection. Usually the projector is on the same side of the screen as the audience, who view the pictures by reflected light. In back projection a translucent screen is used, and from the point of view of the audience the projector is behind it. The advantage is that greater brilliance can be obtained, so back-projection is often used when the projected pictures have to be viewed in an incompletely darkened room. Disadvantages are the extra space occupied, even if the projector uses a wide-angle lens, and if the light-scattering power of the screen is not high enough there may be a bright patch on the screen between the viewer's eye and the lens. (See PROJECTION LAMPS.)

Ball and Tube Release. See PNEUMATIC RELEASE.

Balsaming, Re-, of Lenses. In order to reduce reflection and consequent degradation of image, those contact surfaces of lenses which are ground to the same curve are usually cemented together with Canada balsam. Occasionally these cemented surfaces separate more or less completely, or the balsam undergoes a kind of congelation; while occasionally it becomes yellow. The process of separation, cleaning and

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recementing which then becomes necessary is best left to the maker.

"Barometer," Photographic. A bromide print of a landscape subject should be carefully coated or brushed over with the following mixture, after first thoroughly being hardened in a 10 per cent. formalin bath :—

Water	3½ oz. (100 c.c.)
Gelatine	90 gr. (6 gm.)

Dissolve by the aid of heat, and add—

Cobalt chloride . . .	30 gr. (2 gm.)
Glycerine (water-free) . .	20 drops (1¼ c.c.)

The part brushed will become blue in fine weather and pink in damp weather, owing to the action of moisture on the cobalt salt. Since it indicates the moisture-content, and not the pressure, of the atmosphere, the print so treated is a hygrometer, not a barometer.

Baryta Paper (Ger., *Kreide-papier*, or *Baryt-papier*). Paper coated with an emulsion of barium sulphate in gelatine made partly insoluble by chrome alum, used as a support for all types of sensitive emulsion printing, for collotype printing etc. A formula for its preparation is the following :—

I.

Gelatine	90 gr. (8·25 gm.)
Barium chloride . . .	30 gr. (2·75 gm.)
Distilled water . . .	5 oz. (200 c.c.)

II.

Ammonium sulphate . .	15 gr. (1·35 gm.)
Distilled water . . .	2½ oz. (100 c.c.)

Soak the gelatine in the water till soft, add the barium, and dissolve by heat ; then add solution II in small quantities, shaking between each addition ; allow the emulsion to set ; break up into small pieces ; wash thoroughly, and add 7½ gr. (0·7 gm.) of chrome alum previously dissolved in a little water. (See EMULSIONS.)

Base, and Basic. An approximate definition of a base is that it is a substance which will react with an acid to form water and a salt. To this extent " base " is synonymous with " alkali," but the former term is much wider ; every alkali is a base, but by no means every base is an alkali. To qualify as an alkali, a base must be soluble in water ; it then imparts

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to the solution the soapiness of feel and ability to turn red litmus blue that characterize an alkali. Iron rust, for example, will dissolve in acid, neutralizing it and forming a salt, so it is a base ; but it has no alkaline properties.

Basic salts are those in which the base has been incompletely neutralised by acid ; they therefore contain one or more OH groups or their equivalent. Ferric iron and lead are especially prone to form basic salts.

Baskett's Reducer. Named after R. Baskett, who first suggested the method. It consists of an abrasive mixture for rubbing on the part of the negative to be reduced. It is excellent for local reduction, and is made as follows :—

Ordinary terebene	1 part
Salad oil	1 part
Globe metal polish (paste) . . .	1 part

Mix thoroughly and strain through fine muslin. A few drops on a small pad of cotton-wool or linen should be carefully but firmly rubbed on the part requiring reduction. When reduced sufficiently, clean the surface of negative with a pledget of cotton-wool soaked in benzene. (See REDUCTION, OF DENSITY.)

It is worth adding that Baskett's reducer is invaluable for removing scum or surface deposits of any kind from negatives, and that an equivalent preparation is available ready-made under the name Frictol (Vanguard Manufacturing Co.)

Bas-reliefs, Photographic. If a transparency, on glass or film, is made from a negative, and has about the same contrast as the negative itself, the two, placed together in register, will show an even density practically devoid of any image. If now one is moved slightly over the other, the image will re-appear in outline form, each detail being shown by a dark line along one edge and a light one along the opposite edge. A print made from the combination will give the effect of a bas-relief.

A negative always shows some trace of surface modelling or relief, this relief being more especially noticeable when the gelatine is thick and a pyrocatechin developer is used. But the relief is certainly not enough to make it worth while to cast or mould for decorative use.

An old photo-relief method due to the late Professor Namias is as follows :—An ounce (30 gm.) of fine gelatine is

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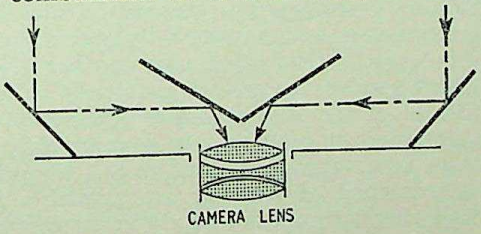
soaked in 3½ oz. (105 c.c.) of water, and the vessel is heated in a water bath until all is dissolved, after which 1 fluid drachm (3.75 c.c.) of glycerine is stirred in. The mixture, having been strained through fine muslin, is poured on levelled glass or metal plates, 1 fluid drachm being allowed for 3 sq. in. of surface (18·5 c.c per 100 sq. cm.). When dry the coated plates may be kept any length of time, and sensitising is performed by soaking a plate for 15 minutes in a 6 per cent. solution of ammonium bichromate, and drying in the dark. Exposure under a negative in the printing frame should be continued sufficiently long to give a fully detailed image in brown, the time required being about the same as would be involved in making a print on ordinary print-out paper. On soaking the exposed plate in water the relief is produced, and the plate can be moulded with plaster or with a waxy composition upon which an electrotype is made.

Battery-Capacitor Flashgun. See FLASHGUN.

Beamsplitter. A combination of four mirrors, or their equivalent, arranged as in the sketch and used either for taking a stereoscopic pair of pictures with an ordinary single-lens camera, or for projecting or viewing a stereo pair so made.



Belitzski's Reducer. See REDUCTION, OF DENSITY.

Bellows. The folding portion of the camera which unites the back and front portions is called the bellows, and is usually constructed of leather or black cloth. Black sticking plaster is useful for repairing small damages to bellows. The following has been recommended for renovating leather bellows and leather camera coverings generally. Mix—

Sperm oil	3 oz.	(85 c.c.)
Acetic acid	3 dr.	(11 c.c.)
Glycerine	3 dr.	(11 c.c.)
Oil of turpentine	½ oz.	(14 c.c.)
Water to	15 oz.	(425 c.c.)

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Beutler Method

Add the mixture slowly to the white of 3 eggs, using an egg-beater, and then add 3 oz. (85 c.c.) of methylated spirit and about 100 gr. (6·5 gm.) of aniline black dye.

A reviver for cloth bellows can be made as follows :—

Methylated spirit . . .	16 oz. (500 c.c.)
Shellac	4 oz. (125 gm.)
Oxalic acid	¼ oz. (8 gm.)

Shake until dissolved, then add—

Linseed oil	3 oz. (95 c.c.)

If the bellows are black, give them a preliminary coating of Indian ink dissolved in water, with a trace of Prussian blue to kill the brownness. When dry, apply reviver, using a pad of cotton-wool, and finally removing the surplus by brisk rubbing. (See also LEATHER and MARINE GLUE.)

Beutler Method. Term applied to a method of working popularized by Willi Beutler, of Germany, and now adopted by many users of miniature cameras. It reverses the usual plan of choosing a fast film and relying on a fine-grain developer to keep graininess low; instead, a slow film of inherently low graininess is used, and the developer is chosen to give maximum film speed. The advantage is that the resulting negatives give considerably greater sharpness of detail, especially if the film is of the thin-emulsion type; the disadvantage is that thin-emulsion films tend to have much lower exposure latitude than more thickly coated ones. Proprietary developers for this method of working are available (see p. 209), but the following formula is entirely satisfactory.

A.	Metol	90 gr.	(10 gm.)
	Sod. sulphite (anhydr) ..	1 oz.	(50 gm.)
	Water to	20 oz.	(1000 c.c.)
B.	Sod. carbonate (anhydr)	1 oz.	(50 gm.)
	Water to	20 oz.	(1000 c.c.)

For use, add 1 part A and 1 part B to 10 parts of water. Development time, 7 to 10 min. at 65° for slow thin-emulsion films. In this method of working care should be taken not to give more than the necessary minimum of exposure.

Bibliography. See BOOKS ON PHOTOGRAPHY.

Bichromate Methods. Processes in which the material sensitive to light is an alkaline bichromate in contact with an organic colloid, such as gum, albumen, or gelatine. Most methods of photographic block and plate making come under

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this heading. (See GUM-BICHROMATE PROCESS, CARBON PROCESS, ARTIGUE'S PROCESS, *Intaglio Process* and *Collotype* under PHOTO-MECHANICAL PRINTING PROCESSES, ANILINE PROCESS, CARBRO PROCESS, OIL-TRANSFER and BROMOIL PROCESSES. For bichromate poisoning see SKIN.)

Bichromate of Potash. See POTASSIUM BICHROMATE.

Biconcave. An optical term denoting that the two sides of a lens are hollowed out. (See LENS.)

Biconvex. An optical term denoting that the two sides of a lens are bulged out. (See LENS.)

Binocular Camera. Another name for stereoscopic camera or for camera with twin-lens finder.

Binocular Vision. Seeing with two eyes, as contrasted with one. Binocular vision is necessary for perceiving the depth or distance of an object. (See STEREOSCOPIC PHOTOGRAPHY.)

Bipack. Plate or film coated with two independent emulsions, sensitized to different colours. Has been used for a rather crude process of colour photography.

Birds, Photographing. See NATURE PHOTOGRAPHY.

Bitumen. See ASPHALT PROCESS.

Black and White, Finishing photographs in. (See BROMIDE PAPER, ENLARGING, and AIR BRUSH.)

Black Body. Term applied to a theoretically perfect radiator, totally absorbing all radiation that falls upon it. (See COLOUR-TEMPERATURE.)

Black Lightning. See CLAYDEN EFFECT.

Blacking. The interior of all cameras, dark slides, and lens tubes should be coated with a dead black to prevent the reflection of light and consequent fog on the plate. A good black can be made by grinding lamp or ivory black into a paste with japanners' gold size. Another method is by coating the wood, etc., with a solution of ferrous sulphate, and, when dry, applying a solution of tannin or decoction of logwood, two or three successive applications being sometimes necessary. For blackening brass parts, two or three different methods are employed. Where the brass will not be touched by the fingers, drop-black ground up with weak glue and water may serve, but a better finish, and a more lasting one, can be

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made by mixing fine lampblack with lacquer, and applying it in two or three successive coats to the heated article; but where the brass will be fingered, it is obvious that some other method must be employed. We have the choice of two, one of which results in a bronze colour, the other is a non-reflecting dead black. For the former colour, a solution of platinic chloride acidified with nitric acid is used. This method is especially useful where any soldered joints exist; where solder is not used, an absolute dead black can be obtained by dipping the article, heated fairly hot, into a solution of copper nitrate made by dissolving copper wire in dilute nitric acid; it is then heated over a Bunsen burner or spirit lamp, the green colour of the copper first showing, and at the proper temperature a fine dead black appears. Another method is to dissolve 1 part of copper carbonate in 8 parts of solution of ammonia and adding 18 parts of water. Clean the brass well and immerse in the solution till black, rinse with water, dry in bran or sawdust, and give a rub over with thin oil varnish.

Another formula to blacken wood is as follows :—

Extract of logwood . .	½ oz. (15 gm.)
Potassium chromate . .	30 gr. (1·95 gm.)
Water	35 oz. (1000 c.c.)

Dissolve the extract in boiling water, add the chromate also in solution. This is a deep violet liquid which changes to black in contact with the wood.

To blacken leather-covered hand cameras which have become shabby, the following may be useful :—

Glue	4 oz.	(135 gm.)
Vinegar	1½ pint.	(1000 c.c.)
Gum arabic	2 oz.	(66 gm.)
Black ink	8 oz.	(270 c.c.)
Isinglass	120 gr.	(9 gm.)

Break the glue in pieces, put in a basin, pour over it about two-thirds of the vinegar, let it stand till it becomes perfectly soft. Put the gum in another vessel with the ink until it is perfectly dissolved: melt the isinglass in as much water as will cover it, which may be easily done by placing the cup near the fire about an hour before required for use. To mix them, pour the remaining vinegar with the softened glue into a vessel and heat on a sand bath over a gentle fire; stir till dissolved, and do not let heat be over 80° C. Add the gum and heat to 80° C., add the isinglass, and it is ready for use. Put as much as

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required in a saucer, beat it till thin, and apply with a small sponge. If the article is dried quickly in the sun or before the fire it will have a better polish.

The following methods have been recommended for blackening aluminium :—

(1) The metal is well rubbed with a clean rag and strong kitchen soda and water, to get rid of any grease. It is then coated with albumen by beating up the white of an egg and straining it through muslin. The albumen coating is allowed to dry, and then heated to a dull red heat, and allowed to cool.

(2) Clean the surface thoroughly with fine emery powder or emery cloth, then give it an even coating with olive oil, and heat it over a spirit lamp until it turns black.

(3) Prepare the following mixture :—

Hydrochloric acid . . .	1½ oz.	(50 c.c.)
Ferrous sulphate . . .	60 gr.	(4.6 gm.)
White arsenic (arsenious oxide)	60 gr.	(4.6 gm.)
Water	1½ oz.	(50 c.c.)

The aluminium is first thoroughly cleaned with fine emery cloth, and then dipped in the above "arsenic bronze" bath.

(4) Add 50 gr. (11·5 gm.) of gum sandarac to 1 oz. (100 c.c.) of absolute alcohol; when dissolved add slowly, mixing thoroughly, 3 gr. (0·7 gm.) of nigrosin. Apply this with a soft brush and allow to dry thoroughly before touching it.

Iron enlarging lanterns, if not used frequently, or kept in a damp dark-room, frequently become rusty in parts. To renovate and blacken, the metal work should first be thoroughly cleaned with a little fine emery powder well rubbed in with an oily rag. The emery should be entirely wiped off, and then butter of antimony rubbed on. This should also be cleaned off, and the lantern finally polished with a dry cloth.

An alternative method is to apply the mixture given under (3) above. This should be well rubbed over the iron with a bristle brush. When the metal is dark enough, dry off with fine sawdust, and then rub with linseed oil.

A method of blackening the wood surface of the work bench, and, moreover, producing a finish that appears to be impervious to chemicals spilt upon it, is as follows :—

A.	Ferrous sulphate	4 parts
	Copper sulphate	4 parts
	Potassium permanganate . .	4 parts
	Water to make	100 parts

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Blanchard's Brush

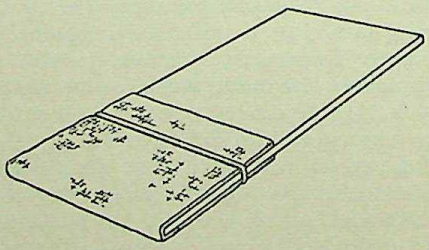
B.	Aniline hydrochloride . . .	15 parts
	Water to make	100 parts

"A" is applied hot with a brush to the bench-top, previously made quite clean (any paint, etc., scraped off), and when dry any excess on the surface is rubbed off. A second coating is similarly given and allowed to dry thoroughly. Then two coats of "B." are given in succession. A black colour is produced which gradually intensifies. A slight coating of linseed oil laid on with a cloth is then given, and the bench is ready for use. Acids and alkalies spilt upon this surface do not appear to affect it if quickly wiped off, and the surface can be kept in good order by an occasional wipe of linseed oil after a course of work.

Where space and other circumstances permit, a lining of black velvet provides the ideal non-reflecting surface for the insides of cameras, extension-tubes, or lens-hoods. Where the thickness of velvet precludes its use, the black velvet-surfaced paper known as "flocks" or "coffin paper" makes an excellent substitute.

(See also BELLOWS, LEATHER, and DARK-ROOM.)

Blanchard's Brush consists of a piece of swansdown calico doubled and fastened by means of an indiarubber band round a strip of glass 2 in. wide and 6 in. long. It was used for



A BLANCHARD BRUSH.

coating plates, etc., with substratum for the collodion process, and is useful in the carbon and oil processes for applying the sensitising solutions evenly. It is a useful tool in any process where paper has to be mopped over with a liquid. (See also BUCKLE BRUSH.)

Bleacher. See DRAWINGS FROM PHOTOGRAPHS, INTENSIFICATION, TONING, and BROMOIL.

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Blisters. This trouble was at one time very prevalent with prints, but is now of very unusual occurrence. Beyond the fact that blisters occur because there are points where the gelatine film is insufficiently adherent to the paper there is little known. There are, nevertheless, certain conditions which seem calculated to produce blisters and which should always be avoided. Any kinking of the paper, especially while it is wet, tends to produce a slight detachment of the film from the paper, and this may increase in size if the print is placed in conditions favourable to the production of blisters.

Any material change in the density of the fluid in which the print is placed is a condition also tending to produce blisters. Two things will give different density :—a considerable variation in temperature and a considerable variation in the strength of a solution. Thus very cold water is denser than water at a higher temperature, and hypo solution is denser than water alone at the same temperature. It is, therefore, a very common instruction to avoid serious variations of temperature in the various solutions, and also to avoid moving the print from a hypo bath direct to the washing water. When blisters occur, a bath of methylated spirit after washing will rapidly reduce them and assist in drying the print quickly.

(See also FRILLING.)

Blocking Out. This term (sometimes called "stopping out") is applied to the method of painting over parts of a negative in opaque pigment so that the light cannot pass when printing. The portions "blocked out" are thus rendered in white in the print. Blocking-out medium or pigment is supplied commercially, or thick water-colour paint, such as Indian red or lamp black, can be used. It is applied with a good pointed brush (sable is best) on the film side. If much detail or an intricate outline has to be followed, it is best to use liquid Indian ink with a fine ball-pointed pen. The negative is best held in a retouching desk and the outline carefully followed with the pen—the light coming through the negative. The pen line can then be broadened with the paint brush, and if large patches, such as the sky in a landscape negative, have to be blocked out, only the outline to the extent of half an inch need be painted out on the film side. The remainder can be covered with a piece of opaque paper.

(See RETOUCHING DESK, and RETOUCHING.)

Blocks for Printing. See PHOTO-MECHANICAL PRINTING PROCESSES.

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Blooming of Lenses : Bloomed Lens. See COATED LENSES.

Blue Printing Process. See CYANOTYPE.

Blurring. Any image of indistinct or doubled outline is said to be blurred. Blurring may be caused by an imperfectly corrected lens, a wrongly-adjusted camera, by condensation of moisture on the lens, by a film or plate not accurately in the focal plane, by incorrect focusing, or by movement of camera or object during the period of exposure. (See also HALATION.)

Body-Release. Mechanism for enabling the shutter to be released by means of a plunger or lever on the body of the camera, so allowing the camera to be firmly and comfortably held at eye-level.

Bolting Silk. This is a fine-meshed material, sometimes known as bolting cloth, used for obtaining diffusion of detail and for canvas-grain effects when printing or making enlargements. In use, the bolting silk is stretched on a light wooden frame. This is held between the lens and bromide paper when exposing the enlargement.

Books on Photography. The following classified list makes no pretensions to completeness, particularly as regards the more elementary books, where there are often many covering much the same ground. The list has been compiled with the intention of including at least one good book—where possible two, one elementary and one more advanced—on every aspect of the subject. Books only temporarily out of print have been included without comment; the few specially important books that are included although permanently out of print are indicated with an asterisk. Most of these are either obtainable secondhand or can be consulted at public libraries, notably the Patent Office Library (Southampton Buildings, Chancery Lane, London) where the enquirer has direct access to the shelves. At the British Museum Library access to the books is less rapid, but the collection is very complete.

Owing to frequent changes, the prices quoted may in many cases be incorrect. They have been included solely as an approximate indication of the size of the various volumes.

In addition to the books listed, many manufacturers issue very valuable booklets either free or at nominal prices.

An up-to-date list of current photographic books by all publishers can be had on application to the Fountain Press.

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ADVANCED SCIENCE OF PHOTOGRAPHY.

The Theory of the Photographic Process. C. E. K. MEES. 150/6.

COMPLETE PHOTOGRAPHIC TEXTBOOKS.

Photography, Theory and Practice. CLERC. Third Edition, revised by British team, not by author, 70/-, Author's Sixth French Edition (1957). *La Technique Photographique*, pub. Paul Montel, Paris.

Photography, its Materials and Processes. NEBLETTE. 75/-

GENERAL TEXTBOOKS.

Ilford Manual of Photography. Ed. MITCHELL. 30/-.
Gevaert Manual of Photography. CRAEYBECKX. 25/-.
Graphic Graflex Photography. MORGAN and MORGAN. 63/-.
Picture Making with the Reflex. NEWCOMBE. 21/-.

ELEMENTARY GENERAL TEXTBOOKS.

Complete Amateur Photographer. BOER. 25/-.
All-in-One Camera Book. EMANUEL. 10/6.
How to Make Good Pictures. KODAK, LTD. 8/6.
Home Photography. JOHNSONS OF HENDON, LTD. 3/-.

ENLARGING, PRINTING AND NEGATIVE MAKING.

Developing. Jacobson. 19/6.
Modern Enlarging Technique. WAKEFIELD and HARRIS. 15/-.
Enlarging. JACOBSON. 21/-.
Complete Art of Printing and Enlarging. CROY. 21/-.
Photographic Enlarging. CHARLES. 7/6.
The Negative, and The Print (Basic Photo Series). ADAMS. 32/6 ea.
Pearlman on Print Quality. 12/6.

MINIATURE PHOTOGRAPHY.

Miniature and Precision Cameras. LIPINSKI. 30/-.
35 mm. Photo Technique. NEWCOMBE. 19/6.
My Way with the Miniature. VINING. 19/6.

See also BOOKS ON SPECIFIC CAMERAS.

PHOTOGRAPHIC SCIENCE: OPTICS, CHEMISTRY, ETC.

The Science of Photography. BAINES. 38/6.
Properties of Photographic Materials. CLERC. 35/-.
Basic Photographic Chemistry. HORNSBY. 15/-.
Photographic Chemistry, Vols. I and II. GLAFKIDES. 105/- ea.
Photographic Optics. COX. 21/-.
Camera Lenses. LOCKETT and LEE. 10/6.
Sensitometry. LOBEL and DUBOIS. 25/-

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Books on Photography

Reference Books.

Focal Encyclopædia of Photography. 105/- (desk edition 35/-).
Photo-Lab Index. Morgan and Morgan. 168/-.

Exposure.

Exposure. Berg. 21/-.
Exposure Manual. Dunn. 45/-.
Wratten Light Filters. Kodak. 12/6.
Focal Filter Chart. Emanuel. 4/6.

Portraiture and Lighting.

Lighting for Photography, and Lighting for Portraiture. Nurnberg. 21/- ea.
Portrait Manual. Coppel and Bomback. 45/-.
Camera Portraiture. Williams. 30/-.
Posing Patterns. Broome. 35/-.
Glamour in Your Lens. Macgregor. 12/6.

Flashlight.

Flash Photography. Heath. 10/6.
Successful Flash Photography. Mannheim. 9/6.

Camera Journalism and Professional Work.

Press Photography in Practice. Harrison. 52/6.
Business Practice for Professional Photographers. Hymers. 42/-.
The Business of Photography. Abel. 16/6.
How to Take Photographs that Editors will Buy. Spillman. 19/6.

Retouching and Finishing.

Colouring, Tinting and Toning Photographs. Walley. 10/6.
Retouching. Croy. 17/6.

Constructional Books and Guides to Specific Cameras.

Build Your Own Enlarger. Stevenson. 9/6.
Making an Enlarger. Wadenoyen. 4/6.
Hints, Tips and Gadgets from "Amateur Photographer". 9/6.

Focal Press publish "Camera Guides" for most well-known cameras and cine cameras, prices from 4/6 to 9/6. Both they and Fountain Press publish more detailed handbooks and manuals on many popular cameras, prices from 15/- to 63/-.

Colour Photography.

Colour Films. Thomson. 42/-.
Colour Prints. Coote. 25/-.

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Successful Colour Photography. THOMSON. 9/6.
Taking Colour Photographs. ASHTON. 12/6.
The Colour Book of Photography. LORELLE. 15/6.
Making and Printing Colour Negatives. VICKERS. 30/-.
Colour Photography for the Amateur. HALL. 21/-.
Amateur Dye Transfer Colour Prints. HANWORTH. 15/-.

ART AND PICTORIALISM.

Photo Composition. BARBER. 35/-.
Erith on Pictorial Photography. ERITH. 32/6.
Modern Control in Photography. ERITH. 32/6.

CINE.

How to Make Good Home Movies. KODAK. 7/6.
Movie Making for Everyone. ALDER. 10/6.
Introduction to Cine. POSTLETHWAITE. 12/6.
Filming with 16 mm. DAVIES. 25/-.
Making 8 mm. Movies. GROSSET. 35/-.
The Complete Technique of Making Films. MONIER. 30/-.
Principles of Cinematography. WHEELER. 63/-.

Fountain Press Cinefacts (2/6 ea.) each cover most aspects, while they also have the much more detailed "Moviebook" series (8/6 ea.). Similarly, Focal Press have the Focal Cine Books—detailed manuals—at 7/6 to 10/6 ea.

SPECIAL SUBJECTS AND TECHNIQUES.

Amateur Photomicrography. JACKSON. 15/6.
Medical Photography. LONGMORE. 60/-.
Creative Table-top Photography. 35/-.
Photographing Models. AHERN. 3/6.
All the Photo Tricks. SMITH. 17/6.
The Technique of Bird Photography. WARHAM. 25/-.
Zoological Photography in Practice. COTT. 52/6.
Camera Afloat. NEWCOMBE. 30/-.
Stereo Photography. SYMONS. 25/-.
Simplified Stereoscopic Photography. WILMAN. 5/-.
Photographic Make-up. EMERALD. 18/6.
How to Photograph Aircraft, Boats, Trains. 7/6 to 8/6.
Making Lantern Slides and Filmstrips. MILNER. 15/6.
and very many others.

Focal Photo Guides (2/6 ea.) each deal with one aspect of photography, likewise Fountain Photofacts (2/6 ea.).

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When searching in a library for information, references can in a great number of cases be traced by consulting files of *The British Journal of Photography Almanac, Photographic Abstracts*, or the *Kodak Abstract Bulletin*.

See also PERIODICALS.

Borax (Fr., *Borax ;* Ital., *Borace ;* Ger., *Borsaures Natron*). $Na_2B_4O_7{,}10H_2O = 382$. Synonyms: Sodium borate, or biborate. It occurs in hexagonal prisms with 47 per cent. of water; these are often so fine as to have the appearance of an amorphous white powder. There is also an anhydrous product known as *fused* or *calcined* borax; one part of this is equal to 1·89 parts of the crystals. Borax is found native in various parts of the world, or made by neutralising boric acid with soda. Solubility of crystals: 3 per cent. in cold, 68 per cent. in hot water; very little soluble in alcohol, 60 per cent. in glycerine. It is used as a weak alkali in many developers of fine-grain type. (See DEVELOPMENT and FINE-GRAIN DEVELOPMENT.)

Boric Acid. (Fr. *Acide borique ;* Ger. *Borsäure*) $H_3BO_3 = 62$. Synonyms: Boracic acid, orthoboric acid. Used in conjunction with borax in certain fine-grain developers to maintain a constant alkalinity during use or storage. Solubility, 4 parts in 100 of cold water, 39 parts in 100 of boiling water.

Bottles. Bottles are an important item in the photographer's outfit, especially if he is of an experimental turn of mind and keeps many chemicals. Strong acids should be kept in stoppered bottles. The stoppers should be greased with Vaseline to prevent sticking, and all bottles should always be kept stoppered or corked and legibly labelled. Always pour from a bottle on the side opposite to the label to protect it from contamination by drips.

Bottles may be obtained from the chemist, from laboratory furnishers, or "empties" from all sorts of sources may be accumulated. It is worth noting that most medicine bottles have their capacity, in fluid ounces, moulded on the bottom, and that the ordinary wine or spirit bottle holds one-sixth of a gallon, or 26⅔ oz. (750 c.c.) The large wine bottles (vermouth, Chianti) generally hold 1 litre, or 35 oz., while beer bottles hold 10, 20, or 40 oz. (284, 568, or 1136 c.c.)

Before placing a solution in a bottle it should be thoroughly cleaned. The following are the best cleansing agents for removing traces of various substances from bottles:—

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Oil, Fat, Greasy Solutions.—Any strong alkali—*e.g.* ammonia, caustic potash, or soda, etc.

Glycerine.—Use plenty of warm water.

Resins, Varnish, etc.—Warm methylated spirit, and, failing that, a strong solution of potassium carbonate.

Tinctures, Scents.—Methylated spirit, followed by strong ammonia and then water.

Spent Developers.—Strong hydrochloric acid, followed by fine sand and water. A grey deposit of metallic silver is best removed with nitric acid, or with the cleanser given under *Physical Development* in the article FINE GRAIN DEVELOPMENT.

Chalky Incrustations.—Dilute hydrochloric acid and then plenty of warm water.

(See also CORKS, and LABELS.)

Broken Negatives. When a glass negative is broken, lay the negative, film downward, upon a perfectly level surface, carefully place the fractured pieces together, and apply strips of gummed paper along the edges of the negative. When thoroughly dry, turn the negative over, and apply some strips of paper along the margin on the film side; allow it to thoroughly dry, and varnish the film. To print from broken negatives, lay the frames on a revolving gramophone turn-table, or place them at the bottom of a box without a lid, about 18 in. deep. When the negative is badly broken in many pieces, a good plan is to sandwich the pieces between two clean glasses of the same size, and bind all together like a lantern slide. A positive on another plate should then be made by copying in the camera. This can be retouched, and a new negative made from it and again retouched.

Another method for dealing with the crack is to drop some Canada balsam, well diluted with xylol, in it; this, on drying, renders the glass and crack homogeneous.

Broloid. A process, demonstrated by Oswald Stein to the Royal Photographic Society in 1940, by which the image on a bromide print can be reinforced or replaced by a pigment image. Working details have not been published, but the process appears to have a certain likeness to the Carbro or Carbograph processes (*q.v.*).

Brometching. A method of treating bromide paper (*q.v.*) so as to produce a result showing the texture of the paper support, thus giving the print a character reminiscent of an

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etching. The process was first described by Richard Lluellyn in *The Amateur Photographer* for October 9th, 1935.

The choice of paper for this process is important, as the true character of the " brometching " is most fully developed on a paper of rough or extra rough texture.

The paper is given from two to six times the normal exposure, and is then developed fully, giving some fifty per cent. more than the normal time to allow the over-printed darks to reach their full blackness. Rinse the print in water, and transfer to the etching solution, which is made up as follows :—

Salt, 25 per cent. solution . . .	3 parts
Sulphuric acid, 12 per cent. solution .	1 part
Potassium permanganate, 2½ per cent. solution	6 parts
Water	240 to 320 parts

The separate solutions keep well, but the working solution should only be mixed at the time of use. The weaker solution is used when the exposure has only been about three times normal ; where it has been longer the minimum quantity of water should be taken. A 10 × 12 print will require some 20 oz. (570 c.c.) of the solution.

The method of applying the " etch " is important, as it must not be poured directly on to any part that will appear in the final picture. It is best to mask one end or side of the paper to provide a space on which it can be poured. The use of a dish bigger than the paper is not recommended, as this accentuates the tendency to uneven action towards the edges.

The whole of the etching solution should not be poured on at one time ; about a quarter of the required amount is enough for the first application. As soon as it is poured on, white light may be turned up to enable the progress of the action to be watched. When the etch changes from its original magenta to a brown-red it may be discarded, and a fresh lot poured on. This is continued until the brightest highlight is practically cleared of silver, when the print is washed until the wash-water no longer has a pink tint, and is then transferred to a fixing-bath made generously acid with metabisulphite. The image which up to this point has been flat, veiled, and stained, clears almost at once and stands out boldly in a rich charcoal black.

Uneven action of the etching solution towards the edge of the print or elsewhere is generally due to the print not lying

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quite flat in the dish ; the defect may be prevented by sufficient soaking after development.

Brom-hydroquinone. 1-2-5 bromodihydroxybenzene = 179. Known also as adurol. Developing agent very similar in properties to chlorquinol (*q.v.*) but of rather higher activity. It is no longer commercially obtainable.

Bromide. A salt of hydrobromic acid HBr. The alkaline bromides are used as restrainers in development, and for emulsion making. For individual salts, see under AMMONIUM BROMIDE, POTASSIUM BROMIDE, etc.

Bromide Paper. Paper coated with an emulsion of silver bromide in gelatine, with or without other silver haloids, and intended for obtaining prints by development either by contact printing or enlarging with daylight or artificial light. The emulsion is prepared in a manner similar to that in which the emulsion for dry plates is made. (See EMULSIONS.)

Bromide paper is sold in both single-weight and double-weight thickness, the latter really being very thin card. In most makes a wider variety of surfaces, etc., can be obtained on double-weight paper, which is in any case more suitable for large prints. Surfaces range from glossy to very rough, some being dull (*i.e.* non-reflecting) while others have a distinct sheen. Surfaces of the latter type have quite outrun the former in popularity, largely because the blacks are richer than on a completely non-reflecting surface. Many of the surfaces can be had on either white or cream paper, the latter being particularly suitable for prints that are to be sulphide toned. The "white" papers of some makes are dual-purpose papers ; the base is tinted to a very slight cream or "ivory-white" colour which is effective no matter whether the prints are toned or left black.

In the matter of contrast the worker is well catered for ; some makers offer paper (in certain surfaces only) in as many as five different grades of contrast. Whatever may be the contrast of the negative, one grade or another is bound to yield a good print. (See CONTRAST GRADES.)

An unusual type of bromide paper, introduced in 1940 under the name "Multigrade," combines a contrasty emulsion highly sensitised to yellow light and a soft emulsion sensitive almost solely to blue light. Contrast is then determined *at the time of printing* by using a blue or white light for soft prints, and a yellow light if a contrasty print is required. Any

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desired contrast can be obtained by placing a filter of the correct colour over the light, or, using two filters only, by dividing the total exposure in the required proportions between blue and yellow light.

Different makes, and even different contrast-grades of the same make, have different speeds, but the differences are not great (a ratio of perhaps 5 to 1 among the well-known makes). No attempt to list speeds can ever be more than a very rough guide, as successive batches of nominally identical paper may have quite different speeds. Further, the speed changes quite appreciably during storage. For these reasons it is not worth while to keep records of the exposures required for printing different negatives.

Exposing Bromide Prints.

Operations in the production of a bromide print or enlargement must be conducted in yellow or orange light. The exposure is made by artificial light, and printing should be carried on by the same light always, if possible, to get uniformity of results.

The film side of the bromide paper, even if not evident from the gloss or sheen, can be easily seen by its tendency to curl inwards. If there is any doubt, one corner should be gently but firmly bitten or placed for a few moments between moistened lips; the film side will adhere.

Bromide paper is primarily intended for making enlargements, for which purpose the negative is placed in a kind of projection lantern that forms an image, not on a vertical screen, but in the baseboard of the enlarger (see ENLARGING). After focusing the image to the required size, the enlarger lamp is switched off, the paper placed on the baseboard to receive the image, and the enlarger lamp is switched on long enough to give the paper the correct exposure. It is then developed and fixed.

Exposure is normally determined by making a test-strip. For this a long narrow strip of paper is cut, and laid on the baseboard so that it receives a typical part of the image. This strip is exposed in steps by progressively covering up portions as the exposure continues; the times of exposure should be in geometrical rather than arithmetical progression. This would be achieved if successive portions of the strip were covered over after, say, 2, 4, 8, 16 and 32 seconds from the start of the exposure. Development will show which of these times is nearest correct; finer adjustment between

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adjacent times can be done by guesswork except with very hard papers, when a second test-strip, with less difference between the times, may be needed. When correct exposure has been established, a full sheet may be exposed.

It should always be remembered that bromide paper requires to be developed for its full time; the depth of the print is therefore only controllable by varying exposure. For a given depth of print, there is very little latitude in exposure. Unless fully developed, neither the gradation nor the colour of the print is likely to be satisfactory.

Development of Bromide Prints.

The development of the print must be done in the dark-room by yellow light. The exposed paper is taken from the enlarger baseboard and transferred to the developer, the temperature of which should *never* be below 65° F., and may with advantage be a little higher.

If a good many prints are to be made, so that it is not uneconomical to use a fair volume of developer, the exposed paper may be simply slid, face up, into the solution. With big sheets this is difficult; it is then better to lay the paper, face up, in the empty dish and pour the developer on to it. When the quantity of developer to be used is too small to ensure rapid flooding of the print by either of these methods, it should first be soaked in water till limp, when the developer will spread evenly over its surface without difficulty. It is a good plan to wipe the surface over with cotton-wool, or with the fingers, as soon as the developer is applied. This ensures that there shall be no air-bubbles on the face of the print.

The dish is rocked, or the print moved about in the developer, and if exposure has been correct, the image will make its appearance in a few seconds, and in a normal developer used at 65° F., development will be complete in something less than 2 minutes. With correct exposure, there is little likelihood of over-development, as the action of the liquid seems to stop almost entirely. This is especially the case with amidol. This stoppage of development may be taken as an indication that the process is finished, but should not be relied on to the extent of leaving the print in the developer too long, or the whites of the picture may be degraded.

When the print is judged to be fully developed—and it is well to remember that in the light of the dark-room it will look darker than it will in daylight when finished—it is rinsed and placed straight into the fixing bath.

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Bromide Paper: Development

If the print is too light, exposure has been insufficient, while if it is too dark, exposure has been excessive. In either case another print must be made, readjusting the exposure suitably. If the contrast of the print is too great or too small, again another print must be made, this time using a paper giving less or more contrast. Since the speed of this paper is not likely to be the same as that already used, a fresh test-strip must be made unless the relative speeds of the two papers are already known.

Developers for Bromide Prints.

It is always safest, particularly for the first trials with any individual make of paper, to use the developer recommended by the makers, and given in the instruction sheet accompanying the paper. Often this developer is available in packet or other ready-prepared form. Nevertheless, most bromide papers work well with any well-balanced developer.

The standard types of developer for all bromide papers are metol-hydroquinone and amidol, and of these the former is now by far the most widely used. Makers' formulæ for M.Q. developers do not vary very widely from one to another, except in the amount of bromide included, and the following, which is a mean of the formulæ of the leading makers, can be used with full success with practically any bromide paper. In a full bottle, well corked, the solution will keep for long periods.

Metol . . .	24 gr.	(2·6 gm.)
Sod. sulphite (anhydr.) .	400 gr.	(46 gm.)
Hydroquinone . .	80 gr.	(9 gm.)
Sod. carbonate (anhydr.)	320 gr.	(37 gm.)
Potass. bromide . .	4 gr.	(0·5 gm.)
Water to . . .	20 oz.	(1000 c.c.)

For use, dilute with an equal volume of water. As it stands, this developer contains $\frac{1}{10}$th gr. of bromide per ounce, which is a minimum for any paper. More, up to about five times the quantity shown, should be added if the maker's formula suggests it, or if there is any tendency to fog. Too much bromide will give a greenish black.

An amidol developer is claimed by many to give a finer colour than metol-hydroquinone, but it must be made up within an hour or so of use, and has the disadvantage of staining the fingers a rich brown. The following is a mean of the formulæ of the leading makers.

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Amidol . . .	50 gr.	(6 gm.)
Sod. sulphite (anhydr.) .	240 gr.	(27·5 gm.)
Potass. bromide . .	8 gr.	(0·9 gm.)
Water to . . .	20 oz.	(1000 c.c.)

Variations in the quantity of bromide make much less difference with an amidol developer than with metol-hydroquinone, but the above remarks concerning the effect of too much or too little bromide hold good also with amidol.

It should be noted that with either developer, but particularly with metol-hydroquinone, it is often highly advantageous to replace some or all of the bromide with a developer improver or anti-foggant. (Latitol, One-Four-Two, etc.).

The prints after development should be rinsed in plain water, or in a stop-bath of 2½ per cent. acetic acid or metabisulphite, and then fixed in an acid fixing bath (*q.v.*). The prints should always be well fixed, for which purpose it is a good plan to put them through two fixing baths in succession. When the first bath is exhausted, its place is taken by the second, and a new second bath is brought into use. Economy in hypo is in this way combined with thorough fixing. (See FIXING.)

The prints are next washed for half an hour or more in running water or in a dozen changes of clean water, allowing the prints to remain for 5 minutes in each change. After washing the prints should be treated with a hypo-eliminator (*q.v.*) and pinned up to dry. The edge of a wooden shelf is suitable for the purpose. Large prints may be suspended by clips from a line across a room, laid face up on a towel on the floor, or laid face down on butter muslin stretched on a frame. Drying may be hastened, if necessary, by soaking the prints in methylated spirit after leaving the last washing-water, or they may be dried by heat, especially if a hardening fixer (*q.v.*), has been used. The emulsion will not melt if the print is kept in brisk movement to provide a continuous current of air over its surface, as it is kept cool by the evaporation of the water. A particularly safe method of rapid drying is by a blast of hot air, as from a hair-dryer. When dry they are straightened by passing under the edge of a flat ruler.

Abrasion or stress marks are not often seen, but may sometimes occur on the surface of the prints—especially in the whites. They can be removed when the print is dry by rubbing with cotton-wool wetted with methylated spirit. These marks are most likely to occur on glossy-surfaced bromide paper, particularly if the development has been forced.

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Warm Tones on Bromide Paper.

Brown or warm tones can be secured on bromide paper by development by greatly increasing the exposure and using a very dilute and highly restrained chlorquinol developer, but the method is uncertain. It is very much more satisfactory to use one of the chloro-bromide papers specially made for the production of warm tones.

Very pleasing warm tones, however, can be obtained by using a pyrocatechin developer devoid of preservative. This developer, due to Dr. Julian Smith, is made up by adding, at the time of use, 40 gr. of pyrocatechin to 20 oz. of a 5 per cent. solution of potassium carbonate (4½ gm. to 1000 c.c.). Development must be carried out at about 80° F., or at as high a temperature as the gelatine of the paper will stand. A little bromide may be required to hold fog in check.

The usual method of obtaining brown or red tones on bromide paper is by toning the print. (See TONING.)

Failures in Bromide Printing.

Failures due to incorrect exposure, or choice of paper of the wrong contrast-grade, have already been mentioned. It only remains to add that dark-room light is misleading to those not accustomed to it, and a print that appears correct when seen in the dark-room may turn out, when seen by daylight, both less dark and less contrasty than it did when made.

Stains, usually of yellow or brown colour, are a not uncommon fault. They are in practically every case due to allowing the developer to oxidise in the paper. A quick rinse after development, followed by immersion in a fixing bath containing plenty of metabisulphite, will ensure absence of stains so long as the print is moved about for its first 15 or 20 seconds in the fixer, and is not allowed to float up to the surface.

Restoring Old and Spoilt Bromide Paper.

Bromide paper that has been kept too long, especially if it has become slightly damp in storage, will often give flat and grey prints, and in a bad case may show a mealy fog, especially round the edges. Unless too far gone, a developer-improver, or anti-foggant (Latitol, One-Four-Two), added to the

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developer, will generally prove a remedy. If this proves ineffective, the following treatment, which can also be applied to paper fogged by slight accidental exposure to light, will often save it.

The procedure is as follows. The following bath is made up :

Potassium permanganate .	5 gr.	(0·25 gm.)
Sulphuric acid . . .	30 min.	(1·5 c.c.)
Water	50 oz.	(1000 c.c.)

The stale or fogged bromide paper is soaked in this solution for a minute. It is then transferred to a 2 per cent. solution of (anhydrous) sodium sulphite.

Leave for another minute, rinse, and the paper is ready for use. It may be exposed at once in a wet condition, or can be washed and dried (in the dark-room, of course). The speed of the original paper is decreased approximately one-half by this method.

Controlling Gradation in Bromide Printing.

Choice of suitable developers will give either harder or softer results than a normal M.Q. or amidol developer would give. The following formulæ represent the two extremes.

For Contrasty Results.

Hydroquinone . .	1 oz.	(50 gm.)
Sodium sulphite (anhydr.)	2 oz.	(100 gm.)
Caustic soda . .	1 oz.	(50 gm.)
Potassium bromide .	½ oz.	(25 gm.)
Water to . . .	20 oz.	(1000 c.c.)

Dissolve the caustic soda separately in cold water, and add to the rest of the solution. For use, dilute 1 part of above with 8 parts of water. As this developer tends to give stains, a stop-bath of 2½ per cent. acetic acid should always be used between development and fixing.

For Soft Prints. The concentrated developer given under *Paraminophenol* in the article on DEVELOPMENT gives very soft prints indeed. For use, take 1 part and make up to 20 parts by adding water. Rather stronger blacks will be given if a developer-improver or about 1 to 2 min. per ounce of 10 per cent. potassium bromide solution is added.

For Intermediate Contrast. A. L. M. Sowerby has suggested (*Amateur Photographer*, September 22 and 29, 1943) that the working solutions of the hydroquinone and paraminophenol developers above should be mixed, in any required proportions, to give intermediate contrast. He finds that the

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available contrast-range can be divided into seven equal steps by taking the amounts of the hydroquinone developer shown in the following table, and making up to a total bulk of 10 oz. (200 c.c.) by adding paraminophenol.

	Metric	*British*
Lowest Contrast	None	None
	4 c.c.	1½ dr.
	10 c.c.	½ oz.
	20 c.c.	1 oz.
	40 c.c.	2 oz.
	80 c.c.	4 oz.
Highest Contrast	200 c.c.	10 oz.

The increase or decrease in contrast, produced by changing from one mixture to the next in order in the table, was the same throughout the series with the paper used in the experiments.

The Sterry Process. This process, due to Sterry, is capable of producing a very great softening of gradation. Prepare the following stock solution :—

Potassium bichromate .	1 oz.	(50 gm.)
Water to . . .	20 oz.	(1000 c.c.)
Ammonia (0·880) . .	1 dr.	(6 c.c.)

For use, add from 100 to 200 minims of the above to 10 oz. of water (20 to 40 c.c. per litre).

Expose sufficiently to print through the highlights of the picture, immerse for 3 minutes in the diluted bichromate solution, wash for half a minute, and develop as usual. The strength of the bichromate bath must be adjusted to suit the reduction in contrast required. Any yellow stain due to the bichromate can be discharged, after washing, by immersion in a saturated solution of alum.

Very full details of the Sterry process will be found in the *British Journal of Photography Almanac*, 1933, p. 226.

Retouching and Finishing Bromides.

(See also SPOTTING PRINTS.)

Retouching prints on bromide paper may be effected by means of a lead pencil, or preferably by a mixture of powdered graphite and crayon, a suitable kind of the latter being Conte-

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crayon No. 1, the touches being afterwards worked up with a stump. For the shadows Conte-crayon No. 3 should be used, whilst for the high lights and half-tones a harder crayon, such as No. 0 or No. 1, will be found useful. Special pencils are made for retouching bromide prints and enlargements, which will be found to answer every requirement. Small defects, such as produced by pinholes in the negative, if they occur in a high light or otherwise white place, may be eradicated by scratching out with a lancet or other sharp-pointed knife, or a needle mounted in a penholder. Enlargements on rough-surface paper are specially suitable for colouring with pastels or crayon, water colours, and oil colours, or by means of the air brush. Colouring with pastels or crayons is not difficult, the rough surface of the paper taking the colour well. For water colours it is advisable to gently rub the surface of the enlargement with a pad of fine linen or cotton-wool dipped in weak ammonia water, so as to make the colours take; or diluted solution of ox-gall may be used for the same purpose. The enlargement must be absolutely dry before any colour is applied, or blisters and running of the colours will ensue.

Medium for Bromide Prints and Pigmenting. One of the most popular methods of improving the quality of prints on matt paper is to treat the surface with the medium given under DOPE.

Its effect is to impart a slight gloss to the surface and to add considerably to the depth of tone of the shadows. Alternative formulæ will be found under ENCAUSTIC PASTE.

If the high lights and shadows of the print are to be altered in tone a little oil-colour pigment of the correct colour is added to the medium. The artist's oil pigment sold in tubes is best for the purpose (that known as "blue-black" is admirable for black-and-white prints).

The surface of the print has first to be prepared by rubbing over with plain turpentine applied with a wad of cotton-wool and polished off. A little pigment and medium is then taken up with another wad of cotton-wool and mixed on a piece of glass or a saucer and rubbed all over the print to produce an even grey veil of tone through which the details of the image can be seen. It will then be a comparatively easy matter to rub away high lights and strengthen shadows by means of further pieces of cotton-wool. It is worth noting that water-colour spotting is unaffected by this treatment.

It is not altogether necessary to prepare a special solution for "doping" a print, as various household preparations can

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be pressed into service. Almost any type of colourless wax polish, intended perhaps for floorboards, boots, or furniture, will be found at least reasonably satisfactory, and one writer has definitely recommended the colourless "Meltonian" polish for this purpose. Caution should, however, be exercised in using such a preparation as a medium for oil pigment; a trial or two on a waste print will soon show whether it will be of value in this connection. (See COLOURING PHOTOGRAPHS; also ENLARGING and AIR BRUSH.)

Glazing Bromide Prints. Glossy bromide prints may be given a high glaze by squeegeeing the print whilst wet down to well-polished glass or chrome glazing plate. If the prints show a tendency to stick, they should be soaked in a 5% solution of formalin before squeegeeing. (See GLAZING PRINTS.)

(See DEVELOPMENT, FIXING, WASHING, HYPO-ELIMINATORS, TONING and ENLARGING; also INTENSIFICATION and REDUCTION.)

Bromide Pencils. Special crayon pencils for retouching, spotting out, and working up bromide prints and enlargements.

Bromoil. A process for the production of prints in permanent oil pigments on the photographic base provided by a bromide print or enlargement. It is thus a combination of bromide printing with the oil pigment process (*q.v.*), and the final result, although capable of enormous personal control in the alterations of tone gradations, and even form, may be regarded as a physical development of the bleached image of a bromide print, and therefore a continuation of a purely photographic action. The process is particularly suited for the production of large pictures in pigment, as bromide enlargements can be converted into bromoil prints.

Modern papers are in general rendered unsuitable by reason of a super-coating of gelatine applied to prevent stress-marks, but several makers offer a non-supercoated paper specially for bromoil or Carbro work, and one of these should be chosen. As a good deal depends upon the original bromide print, or, at least, upon the quality of it, it will be as well to devote a few words to this part of the process. Briefly, the print should be of a somewhat shorter tonal range than a print intended to be viewed without modification, it being necessary to avoid extreme darks. Development should not be carried to finality, but should be cut short at about two-thirds of the time usually required to reach this stage. If the factorial

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system be employed with an amidol developer, the factor for full development will be about 12. For bromoil work, a factor of 8 should be adopted. It is, of course, quite possible to get pictures in bromoil from indifferent bromide prints, prints that are thin and flat, or considerably over-exposed and under-developed; but the matter is then more difficult, and only the worker who is skilled in the process will succeed in getting good results.

The developer best suited for the production of bromide prints or enlargements for bromoil is amidol. (See BROMIDE PAPER.)

Having obtained a good bromide print or enlargement, the first part of the process is to convert the black silver image into such a form that the shadow part will "take" an oily ink or pigment, such as lithographic ink, when dabbed on with a special brush, while the high lights repel the pigment.

The print, which should be well fixed and thoroughly washed, may be bleached immediately after the final wash, but with most papers better results are obtained if the print is dried between washing and bleaching.

A great number of formulæ have been put forward for making the bleacher. The following can be recommended :—

10 per cent. copper sulphate solution	¾ oz. (22·5 c.c.)
5 per cent. potassium bichromate solution . . .	½ oz. (15 c.c.)
10 per cent. potassium bromide solution	½ oz. (15 c.c.)
Pure hydrochloric acid . .	2 drops (2 drops)
Water	9 oz. (270 c.c.)

This bleacher should be used at a temperature of 55° to 65° F. Bleaching is complete in about three minutes. When the print is completely bleached so that only a faint yellowish green image can be seen, it should be well rinsed in water and transferred to a bath of 10 per cent. hypo.

The print may then be dried, or may be prepared immediately for pigmenting.

Pigmenting.

To pigment, the bleached print is well soaked in plain water at a temperature of about 70° to 80° F. for 30 to 60 minutes, but the precise time and temperature should be confirmed by

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experiment. It is then placed on a pad of wet blotting paper, and the surface lightly blotted to remove superfluous moisture. Well-washed butter-muslin or fluffless blotting paper can be used for this purpose. When no visible wet can be seen on the surface of the print the " pigment " or " ink " can be applied.

The " inks " for the oil-pigment and bromoil processes are supplied in tubes. Those specially prepared for the purpose are the best, although hard lithographic inks can also be used very successfully. A little is squeezed out on to an opal palette or saucer. If too hard it is worked up a little with megilp or " Roberson's medium " with the aid of a palette knife, but should be still in a fairly stiff condition. If too soft it will simply adhere all over the print, and if too hard it may not adhere at all. Special flat-ended brushes are used for the pigmenting. These are described as " stagfoot " brushes, and the tops are made askew. The best are made of " fitch " hair, and a fairly large one should be used. The pigmenting is done with a soft dabbing action, and it will be found that the action of " hopping " the brush will remove colour, while " dabbing " will deposit it. The correct action can only be learnt with practice, but very little practice will soon give control over the final result aimed at. Do not be in too great a hurry to secure a finished print. Work a little at a time, but not too vigorously, until continued dabbing and hopping produces a well-graduated deposit of pigment on the image. Then gradually work all over the print. Take care that the blotting pad underneath is kept thoroughly wet, but with no drops of water to get on the surface of the print. If this happens they can be blotted off and the print repigmented.

It will be found best at first to apply a very little colour with a gentle action, gradually building up the image by successive applications of pigment. Afterwards it will be possible to apply the colour more boldly and in greater quantities. In this way the heavier shadows can be filled up quickly, and the picture evolved by the gradual removal of superfluous pigment. This latter method is certainly more effective for strong subjects and its speed is in its favour, but it will be as well to start with the other method first until greater certainty is attained. In any case it is always well to have a " pilot " print handy for reference while the pigmenting is progressing. This pilot print may be a small contact print or it may be an enlargement on bromide paper. It will prove a good guide as to what is wanted in the final print, especially if any altera-

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tions in the tones or outlines are indicated. (See OIL-PIGMENT PROCESS.)

Bromoil Transfer. The pigment image of a bromoil print may be transferred to another piece of paper if the bromoil while still wet is brought into contact with the new base, which should be slightly damp and both, suitably protected with paper and card, passed through a roller press. An ordinary mangle will serve, but special presses have been put on the market constructed essentially for the process. After the pigment image has been transferred, the bleached bromide print may be inked up again and another transfer made.

Speaking generally, the same procedure may be adopted for the preparation of the bromide print for transfer as for bromoil, and, as far as suitable papers are concerned, the same remarks apply, except that rough surfaced papers should be avoided for the matrix.

The degree of printing should not be carried any farther than for bromoil, any veiling of the lights proving undesirable, and the extent to which development is allowed to proceed should be much about the same, although, if the negative is at all inclined towards an excess of contrast, the factor may be reduced to 5, or even 4, without adverse effect.

After fixing and washing the bromide print, it should be dried, and the operations of bleaching, fixing, and soaking carried out at any convenient subsequent time, provided that the period does not exceed one month. If it does, it is necessary to raise the temperature of the soaking bath to counteract the hardening of the gelatine that takes place with the lapse of time, the degree of hardening being uncertain. It is permissible, in the case of bromoil, for the print to be dried after bleaching, fixing and washing, and pigmenting deferred, within reasonable limits, until desired, but, while transfers *can* be made from prints so prepared, they do not work so easily or transfer so completely as prints that are inked up immediately after bleaching, fixing, washing and soaking *without* any intermediate drying.

The soaking temperature may be slightly increased for transfer as compared with bromoil. As a general rule, a margin of 5° F. will be sufficient, making the recommended temperatures from 75° to 85° F., but the times of 30 to 60 minutes may stand, although, here again, it is desirable that the precise temperatures and times should be determined by experiment.

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Bromoil Transfer

Inking Up the Print.

Pigmenting, except for small prints which may be inked up in one operation with ink of a suitable consistency, should be arranged in three stages, a hard ink being applied all over the print but of a consistency that will only take to any extent in the extreme darks for the first stage. When this stage is completed, the print must be re-soaked, or rather re-wetted, for a period of not less than 3 minutes, the object being to restore the moisture in the emulsion lost by evaporation. In any event, the print should be re-soaked at intervals of 20 minutes irrespective of the stage to which inking has been carried.

After re-soaking, and provided as much of the hard ink has taken as will, the pigment may be softened or " let down " a little, preferably by the admixture of a softer type of pigment, and applied to the print. As with the harder ink, it should be well worked in all over, and, when this stage is complete, the darks will have very nearly attained their full depth ; the half-tones should be clearly defined and rather lighter than they should be in the finished print ; and the gradations of the lights should be faintly but distinctly visible. The texture, which after inking with the harder ink would be fairly grainy, becomes much smoother, but there is still an appearance of graininess in the image. After re-soaking again, the ink is again let down and applied as before throughout the print. The ink coalesces and the grainy appearance goes ; the tones throughout should be full and very rich ; and the darks may seem a trifle too heavy. The whole print should appear plucky and very brilliant—more so than if it were intended to be the final result. If not, a further re-soaking and another softening of pigment must take place and so forth until the proper degree of brilliance has been obtained.

Transferring the Image.

The print is now ready for transfer in the manner described in the first paragraph, but it should be mentioned that the softening of the pigment, referred to above, should only be done little by little for each stage, and only towards completion should it take with any real rapidity. If the bromoil matrix and the final support are difficult to separate after transferring, it is usually a sign that the ink has not been sufficiently softened in the last stages. If otherwise, sticking

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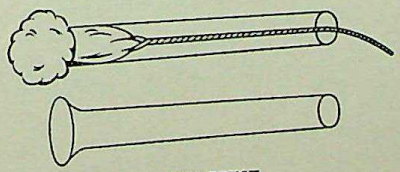
can be prevented by previously spraying the transfer paper with turpentine.

If the darks fail to transfer properly, the cause may rest with insufficient pressure, but it is probable that either the ink has been let down too quickly or the last applications of pigment have not been softened enough, or, perhaps, have not been well worked in. The procedure outlined usually permits of transfer with a single pull, but with the smaller sizes, if the transfer should be too weak, it is generally possible to re-ink the matrix after re-soaking for about 20 to 30 minutes and re-transfer the whole or any part of the image, providing of course, precautions are taken to secure exact registration. In the very large sizes, it is impracticable to make such double pulls, registration being almost impossible on account of uneven stretching of the matrix under pressure, so that only single pulls are feasible. If further transfers are required from the same matrix, it should be soaked immediately for 30 to 60 minutes at the same temperature as originally adopted, the method of inking and transferring being repeated. Three or four transfers may be obtained in succession in this way, but, if the matrix is allowed to dry after the first transfer, the emulsion hardens very rapidly and does not readily lend itself to subsequent treatment.

Brown Tones. See TONING.

Buckle Brush. A convenient little instrument, made by drawing a piece of silver wire bent in half through a piece of small glass tubing, a tuft of cotton-wool being caught in the arch of the wire ; the great advantage of this being that, when dirty, the cotton-wool can easily be replaced. It is convenient



BUCKLE BRUSH.

to turn one end of the tube out like the mouth of a cornet, as shown herewith, as this shape gives firmness and stability to the tuft of wool. A small piece of sponge is often more convenient than cotton-wool, and a piece of string is better than a wire.

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Buffer. Term used in connection with solutions that resist change in acidity or alkalinity. An example will make the principle clear. If half a gram of caustic soda is dissolved in a litre of water, the solution will have a very distinct alkalinity. This alkalinity can be precisely duplicated by replacing the caustic soda with a very much larger amount of a mixture of a moderately alkaline salt, such as sodium metaborate, with an extremely weak acid such as boric acid.

Although these solutions, as they stand, have the same degree of alkalinity, their responses to the addition of acid or alkali are totally different. If half a gram of hydrochloric acid is added to the first solution, the whole of the caustic soda will be converted into common salt, and there will be a little acid over, making the solution faintly acid. But the same amount of hydrochloric acid added to the second solution will convert a small fraction of the sodium metaborate into common salt, turning the boric acid out from the metaborate in the process. This small reduction in the amount of metaborate, even though accompanied by a small increase in the amount of boric acid, will make only a negligibly small change in the alkalinity of the solution. This solution is therefore said to be buffered.

Exactly similar results are observed if alkali—e.g., more caustic soda—is added in place of acid. In the buffered solution the caustic soda will combine with a little of the boric acid to form a little extra metaborate, again making very little difference to the alkalinity.

During the course of development some acid is formed; developing solutions, the activity of which depends upon the degree of alkalinity, are therefore almost always buffered against acid, though not usually against alkali. The necessary buffering is in most cases provided by using an alkaline salt—sodium carbonate, sodium metaborate, and sodium phosphate are the most usual—to provide, and maintain, the required alkalinity. (See also *p*H).

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C

Cabinet. A special size of the commercial photograph, which measures about 6 by 4 in.

Calcium Carbonate (Fr., *Carbonate de chaux ;* Ital., *Carbonate di calce ;* Ger., *Calciumcarbonat, Kohlensaures Kalk, Kreide*). $CaCO_3 = 100$. This occurs native in various forms such as Iceland spar, marble, chalk, etc. It is almost insoluble in water, 0·007 per cent. being taken up by cold and 0·005 per cent. by hot water ; insoluble in alcohol and ether ; it is soluble in water containing carbonic acid, the bicarbonate $CaH_2(CO_3)_2$, being formed. It is used for cleaning glass, in toning-baths, and for preparing other calcium salts.

Calcium Chloride (Fr., *Chlorure de calcium ;* Ital., *Cloruro di calcio ;* Ger., *Calciumchlorid*). $CaCl_2 = 111$. Made by dissolving chalk in hydrochloric acid, and evaporating the solution. One part is soluble in 0·25 part of cold water and 0·15 of hot, in 7 parts of absolute alcohol. The salt is met with in two forms—as a crystalline substance and also in the form of white agglutinated masses. The latter has been used for the preservation of platinotype and other paper, and acts by absorption of the aqueous vapour from the air ; and it will be found in time to become very moist, and, if left long enough, quite liquid. In either case it should be collected in a jar or iron vessel, and placed in a hot oven, when the water absorbed will be driven off and the salt will be as good as new so far as its hygroscopic qualities go. The form of preservative box most used was commonly called a calcium tube.

In modern practice the dehydrating agent used to protect apparatus and materials is silica gel.

Calculations and Constants. Sufficient data for the most important photographic calculations will be found distributed under various headings, as Equivalence, Chemical ; Angle of View, Lens, Thermometry, Weights and Measures, Exposure, Focal Length, Hyperfocal Distance, Shutter,

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and SOLUTIONS AND SOLUBILITY, but in this place a few data are given which do not come under these headings, or which may be conveniently tabulated for ready reference :—

CONSTANTS TO FACILITATE RAPID CALCULATION, MOSTLY GIVEN AS MULTIPLIERS.

Cubic inches	× 0·00058	=cubic feet.
Cubic inches	× 0·01638	=litres.
Cubic feet	× 0·03705	=cubic yards.
Cubic feet	× 6·232	=imperial gallons.
Cubic inches	× 0·003607	=imperial gallons.
Circumference of circle	× 0·2251	=side of inscribed square.
Circumference of circle	× 0·2821	=side of equal square.
Circumference of circle	× 0·31831	=diameter.
Diameter of circle	× 3·1416	=circumference.
Diameter of circle	× 0·7071	=side of inscribed square.
Diameter of circle	× 0·8862	=side of equal square.
Diameter of circle squared	× 0·7854	=area of circle.
Radius	× 6·28318	=circumference.
Circumference	÷ 3·1416	=diameter.
Diameter	.. ..	=1·128 $\sqrt{\text{area of circle}}$.
Radians	× 57·31	=degrees.
Degrees	× 0·01745	=radians.
Length of arc	.. ..	=number of degrees × 0·017453 radius.
Arc of 1° to rad. 1	.. ..	= 0·01745329.
Arc of 1′ to rad. 1	.. ..	= 0·00029088.
Arc of 1″ to rad. 1	.. ..	= 0·000004848.
Volume of prism and cylinder		=base × height.
Volume of cone		=⅓ base × height
Metres	× 3·281	=English feet.
Litres	× 0·2202	=imperial gallons.
Grammes	× 0·002205	=lb. avoirdupois.
Kilograms	× 2·205	=lb. avoirdupois.
Feet per second	× 0·682	=miles per hour.
Miles per hour	× 1·467	=feet per second.
Gallons	× 4·541	=litres.
Grains	× 0·0001429	=lb. avoirdupois.
Pounds avoirdupois	× 7000	=grains.
Pounds avoirdupois	× 0·009	=cwts.
Pounds avoirdupois	× 0·00045	=tons.
Pounds on sq. inch	× 144	=lb. per sq. foot.
Pounds on sq. foot	× 0·007	=lb. per sq. inch.

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Square root of area	× 1·12837	=diameter of equal circle.
Square root of diam. of sphere	× 3·1416	=convex surface.
Candle-power	× 12·56	=lumens.
Lumens	× 0·07962	=candle-power.
Lux		=candle-metre.
Foot-candles	× 10·8	=lux.
Lux	× 0·0985	=foot-candles.
Lamberts	× 10,000	=lumens per sq. metre.
Base of natural logarithms e		=2·71828.
$\text{Log}_{10}x$	× 2·3026	$=\log_e x$.
$\text{Log}_e x$	× 0·4343	$=\log_{10} x$.
Planck's Universal Constant h		$=6{\cdot}55 \times 10^{-27}$ erg-secs.
Velocity of light *in vacuo*		= 299,792,000 metres per sec.
		= 186,282 miles per sec.

Calgon. A proprietary preparation containing or consisting of sodium hexametaphosphate (*q.v.*).

Callier Effect. Increase of contrast of negative when enlarged, or examined, in directed light. (See ENLARGING.)

Calomel. An old name for mercurous chloride.

Calotype, or Talbotype. A process commonly named after its patentee, Fox Talbot, but called by him calotype (καλός, beautiful). It is no longer used, but is interesting as being the first paper negative process used. The following is a short *résumé* of the process:—Stout paper, of an even surface and as grainless as possible, is brushed over with a solution of silver iodide in potassium iodide. It is, when partially dry, washed twice or three times in distilled water to remove the potassium iodide and dried, and it can be kept for some little time in this state, as it is but faintly sensitive to light. When required for exposure it is brushed over with a solution of gallo-nitrate of silver or aceto-gallo-nitrate, and exposed wet; the exposure required for an open view is about 6 minutes. In all cases a faint image of sky-line should be apparent. The image is developed with a solution of gallo-nitrate of silver in excess of gallic acid. The negative is well washed, fixed in hypo, and washed and dried in the usual way, then waxed or oiled to render it translucent.

Camera. The old term *camera obscura*, or *dark chamber*, is now shortened into camera, excepting in a few cases where an

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old-style tent-camera is used as an exhibition at a sea-side or holiday resort. Every form of camera now used is actually a dark chamber or box into which the image of external objects may be projected by means of a lens or other image-forming device. In the pre-photographic days portable camera obscuras were made, by means of which the images of external objects were projected upon a sheet of white paper, and the outlines traced by means of a pencil. The first photographic camera of Nicephore Niepce appears to have been constructed about the year 1816, and in a letter written during that year he describes it as " a sort of artificial eye consisting of a square box fitted with an adjustable tube containing a lens."

The earliest Daguerreotype cameras (1839) were plain boxes which had to be taken whole into the dark-room. Then came the dark slide, and soon after the introduction of Talbotype (or Calotype) in 1844, attempts were made to construct light and portable forms of camera for tourists. The first were made with sliding bodies of wood, but soon lighter bodies were formed of a stretched bag of textile material or a light bellows. The Kinnear Folding Camera of 1860, the first made with tapering bellows, marks a period. Most modern folding cameras are founded, however distantly, on this model.

To describe in detail all the many patterns of camera that have since been produced would be impracticable, but the following notes give some idea of the main types that have been outstandingly important in the past or are now current.

The Stand, or Field, Camera. (Wooden). A stand camera is always fitted with a focusing screen on which the image is focused and arranged with the lens open ; this is then closed, a dark-slide is put in to replace the screen, and the exposure is made.

The typical instrument of this class has two flat frames—front (for lens) and back (for dark slide)—united only by bellows. In erecting it, front and back are independently slid or clamped on to the horizontal bed, along which one or both can be moved for focusing by a rack and pinion device. Often the bed itself, consisting of two frames of square U shape, can also be extended or retracted. Many such cameras required their tripod as part of their base ; all were impossibly inconvenient to use in the hand. Consequently they were fitted with many " movements " ; front and back could be moved independently, they could be tipped forward, backward, or sideways, there was extensive rising front and long extension, the lens panel was removable for changing lenses, and the

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reversing back could be removed and replaced so as to bring either long or short side of the plate into the vertical position.

In the early models a cap was used for exposure ; later this was replaced by various crude shutters, but eventually the roller-blind shutter (see SHUTTER) became standard on this type of camera.

For difficult work—*e.g.* architecture or copying—and where time and convenience are of less importance than the ability to obtain the best possible result, the stand camera is still widely used by professional and commercial photographers, though seldom by the amateur. Some workers continue to use the old wooden cameras, often of considerable age, but modern and re-designed all-metal stand cameras are now available. The most versatile of these is probably the " monorail " camera, built on the lines of an optical bench and having a monorail base on which various alternative parts can be assembled. If he has a good selection of such parts, the photographer can virtually build himself a special camera for the job in hand.

The Hand-or-Stand Camera (Wooden). This represents an attempt to retain all the movements of the stand camera in a version suited also for snapshotting. The straight bed of the stand camera becomes a folding baseboard, the backward continuation of which is the bottom of a shallow box housing the lens panel and bellows when the camera is closed. To extend the camera into the operating position, the carriage bearing the lens-panel is drawn out along runners on the baseboard and clamped to them in a suitable position ; for focusing, or for extra extension, the runners themselves move forward by a rack-and-pinion motion.

In the early years of the century this type, of which the Sanderson is the most famous example, had an enormous vogue among amateurs, and it remains probably the most versatile type of camera ever produced. For amateur work it is virtually obsolete in Britain, save for one or two specialised branches of work such as architecture, but modern all-metal versions (M.P.P., Linhof, Speed Graphic) are widely used by professional and commercial workers and by some advanced amateurs. Shutters, usually diaphragm (between-lens.)

The Folding Plate Camera (Wood ; later metal). This represents a simplification of the last type ; the reversing back and removable lens-panel are discarded, together with swing movements to front and back, though the rising front is retained. The focusing movement was usually by rack and

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pinion, but sometimes by lever or simple slide (see FOCUSING.) Double extension was by no means invariably available. Lenses at first were the simple achromatic or rapid rectilinear, but anastigmats were later fitted to the better models. Earlier models were of wood, later ones entirely of metal, with metal dark slides each holding one plate, and often an adapter for filmpacks, and in later years for roll films, as well. Shutters were almost always of diaphragm type. Although once very popular (about 1908 to 1925), this type of camera is no longer made; it has neither the versatility of the true "hand-and-stand" models, nor the convenience for snapshotting offered by instruments of more modern design. And in any case amateurs have now almost entirely discarded plates in favour of roll films.

Box-Form Cameras. In the early days of roll films (*circa* 1900), the box-form camera was usual. This consisted of a rigid box holding the lens permanently at the correct distance from the film for sharp focus, and containing a long roll of film—at first on a paper base, then on celluloid as now. This was loaded into the camera at the factory, to which the complete camera was returned for reloading and to have the exposed film developed. One roll might accomodate up to a hundred exposures. Later, the celluloid film was superseded by the modern type of paper-protected roll film for daylight loading.

Box cameras for plates in sheaths were at one time very popular but have been obsolete for so long that even secondhand ones are now but rarely met. The high-water mark of this type was probably the N. & G. "Special B" for plates in dark slides, with anastigmat lens in multi-speed shutter.

Modern box-form cameras are all inexpensive, and all take roll film. A slow single lens (usually *f*/14 or thereabouts), sometimes with rudimentary focusing adjustment, a single-speed shutter with "time" movement, and a pair of view-finders; this represents the usual equipment.

Several current box-form cameras have over-size—even life-size—brilliant reflecting finders, giving them a superficial likeness to a twin-lens reflex, and some even have names that suggest they actually are reflex cameras. They cannot in fact be so classed, as the finder gives no aid in focusing. A few cameras of this general type have been fitted with high-grade lenses and shutters, taking them well outside the class of box cameras as the term is usually applied.

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The Folding Roll Film Camera. The early models of folding roll film camera were simply folding plate cameras with a body adapted to take roll films in place of plates in dark slides ; many, indeed, would take either. But the film version later evolved into what was virtually a new type. The folding baseboard along which the front supporting the lens panel had to be drawn in opening the camera ceased to carry the lens panel and became mainly a cover, the front being rigidly supported at a fixed extension by a system of self-erecting struts. Focusing was taken care of, not by moving the lens-panel bodily, but either by screwing the lens and shutter in and out of it on a helical focusing thread, or, more commonly, by screwing the front component only of the lens in and out, leaving the shutter and the rest of the lens immovable. The provision of an eyelevel finder and a shutter release on the body of the camera finally turned this type into a convenient and quick-acting snapshot camera. This type of camera, for roll-film sizes, tends to give a better performance for its price than any other, and so was the most popular amateur type from about 1930 to perhaps 1950, but the phenomenal rise in popularity of the 35 mm. miniature and the 6 × 6 cm. twin-lens reflex has led to the virtual extinction of the folding roll-film camera.

Focal-Plane "Press" Cameras. The folding focal-plane camera was introduced last century to give the Pressman, who frequently needs to take moving objects, the advantage of the only reliable and quick-working shutter then available. The typical Press camera consists of a frame containing the shutter, fitted at the back for plates in dark slides and with the lens carried on a flat panel supported at the four corners by struts and connected with the camera body by bellows. There is no baseboard ; for folding the struts collapse and the front goes straight back on to the body, leaving the lens exposed. Focusing is done by focusing mount, as the camera has fixed extension. In early models the body was of wood, the shutter was a simple blind the slit in which was altered by strings or chains on the shutter blind itself. Winding the shutter with the slide open and no cap on the lens meant a fogged plate. By degrees the shutter was elaborated ; it became controllable by knobs outside the camera and was made "self-capping," by which is meant that the slit is closed during winding and only opens when the blind returns to make the exposure. It is quite the most convenient and quickly-used snapshot camera for plates that has ever

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been produced, and though never much used by amateurs, is still liked by many of the older Pressmen.

The Focal-Plane Miniature. Miniatures using cine film and fitted with a focal-plane shutter (Leica : Contax), are the lineal descendants of the Press camera. The collapsing front is replaced by a draw-out tube for the lens, and a long roll of cine film, automatically advanced by the act of winding the shutter, replaces the more cumbersome plates in dark slides. Otherwise there is no fundamental difference but size. To the outstanding advantage of the Press camera it therefore adds further special advantages of its own. It has been elaborated with coupled rangefinder, interchangeable lenses of many different foci, special accessories allowing it to be used conveniently and successfully for a wide range of work—such as copying, for which its fundamental design is really unsuitable. It offers the unique advantage, largely made possible by the small size of picture made, of being capable of taking lenses of extreme apertures. *f*/2 is usual, *f*/1·5 not uncommon, and *f*/0·95 not unknown; such apertures allow of work in almost any conditions of lighting, natural or artificial.

Other Miniatures. In addition to the focal-plane miniatures, which were the first of the cinefilm cameras, there are many fitted with between-lens shutters, which are more easily synchronized for flash (*q.v.*) than the focal-plane shutter. Many early ones were modelled on the folding roll-film camera, but now all are of rigid construction with the lens permanently at normal extension. In many a behind-lens shutter is used and the lens is interchangeable with others of different focal length, and in a few models the focal length of the lens can be altered, without altering camera extension, by replacing the front component of the normal lens by another. (See also MINIATURE CAMERAS.)

The Reflex Camera. The reflex camera (*q.v.*), originated early in the century as a cumbersome wooden box-form structure for plates in dark slides. In this type of instrument the image formed by the lens is reflected, by means of a mirror, to a horizontal focusing screen at the top of the camera. (See diagram.) In the single-lens reflex, to which class all the early instruments belonged, pressure on the release first lifts the mirror or allows it to spring up, thus covering the top focusing screen, and then releases the focal-plane shutter lying immediately in front of the plate or film. In spite of the considerable bulk and weight of a wooden camera, with revolving or reversing back, built on the lines of the sketch, the great

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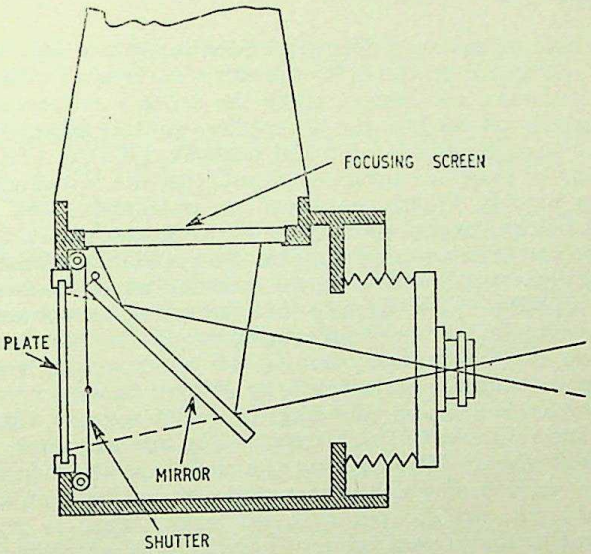

FIG. 1. Single-Lens Reflex.

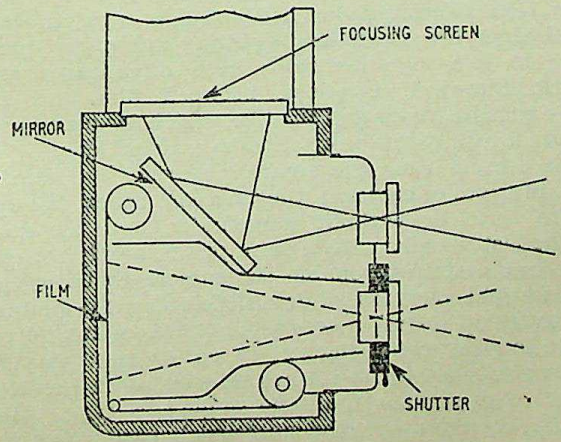

FIG. 2. Twin-Lens Reflex.

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advantage of having a focusing screen instead of only a view-finder, doubly appreciated by the early workers accustomed to stand cameras, has always made the reflex a favourite type, particularly as the use of a focal-plane shutter allowed lenses of long focal length to be fitted without difficulty. A sharp lowering of prices in 1913, combined with the introduction of folding models, greatly enhanced its popularity, and in the early nineteen-twenties amateurs used reflexes widely.

With the drift towards roll film the popularity of the reflex waned again until revived by the introduction of the small all-metal roll-film reflex, usually for pictures 2¼ in. square, thus neatly avoiding the need for a reversing back. Of this there are two main patterns. One is the single-lens reflex with focal-plane shutter, built simply as a small modern version of the original reflex and retaining all its advantages, including ready interchangeability of lenses. The second pattern is the twin-lens reflex. This consists of a rigid box which forms the camera, on top of which is mounted a structure such as that shown in the sketch, but with the mirror fixed in position. The lens in the camera proper (lower half) is matched to that in the reflecting view-finder (top half) and the two move together for focusing. The image seen on the top screen is thus an approximate duplicate of that which will appear on the film, and if the former is sharply focused, so also will be the latter. A diaphragm shutter is generally used in a twin-lens camera. This latter type has been brought to higher perfection in detail than the single-lens version, and offers great convenience in use, together with such advantages as rapid automatic filmwind, interlock between film and shutter, coupled exposure meter and the like, which for many outweigh the disadvantage of the restriction to a single lens.

At the present time the amateur market is dominated by three main types of camera; the twin-lens reflex, the eye-level miniature, with or without rangefinder, and the miniature reflex, the last usually with a pentaprism, partly for eye-level viewing, but mainly to enable the camera to be used on its side for upright pictures while still keeping the picture seen the right way up. Only a very few cameras of any importance are made for sizes other than 2¼ in. sq. or 24 × 36 mm., and in the former size almost all are reflexes, with the twin-lens reflex far more popular than the single-lens type. But it is the 35-mm. camera that is the most widely used today, whether as a simple model with *f*/3·5 lens, three-speed shutter, scale focusing, and no refinements, or as a complex instrument with

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coupled rangefinder or reflex focussing, coupled exposure-meter and fitted for interchangeable lenses. (See MINIATURE CAMERAS.)

Camera-Shake. Movement of the camera during the period of exposure. (See HAND CAMERA WORK; also BLURRING.)

Canada Balsam (Fr., *Baume du Canada;* Ital., *Balsamo del Canada;* Ger., *Canadabalsam*). Synonym: Canada Turpentine. A pale greenish and faintly yellow turpentine obtained from various species of pine trees. It has the consistence of honey, and a pleasant resinous odour. It slowly dries by exposure to the air into a transparent adhesive varnish. Insoluble in water, soluble in all proportions in alcohol. It is used for making varnishes, and for cementing lenses together, its refractive index being approximately the same as glass. The most useful solvents of the balsam are xylene and benzene. (See BALSAMING, RE-, OF LENSES.)

Candid Photography. Term originally applied to photography of people without their knowledge, but now often used to include any unposed photograph.

Candela. Modern unit of luminous intensity, based on the radiation emitted by molten platinum at its temperature of solidification. The candela is very close in magnitude to the standard candle it replaces, and an ordinary domestic candle provides a standard adequately accurate for much amateur work.

Candela-Metre, or Metre-Candela. Unit of illumination, now usually known as the *lux*. The illumination on a surface placed at one metre from a light source of luminous intensity one candela is one candela-metre, or one lux. (See also CANDELA-METRE-SECOND; LUMEN; LUX; CANDLE-POWER, CANDLE, STANDARD.)

Candela-Metre-Second or C.M.S. Unit of exposure, now usually known as the lux-second. If an illumination of one candela-metre or one lux falls on a sensitive photographic surface for a period of one second, that surface has received an exposure of one candela-metre-second. (See CANDELA-METRE.)

Candelas per Square Foot. Unit in which the brightness of a surface is measured. If a white surface reflecting 100 per cent. of incident light receives an illumination of 3·14

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foot-candelas, it will have a brightness of 1 candela per square foot or 3·14 foot-lamberts (*q.v.*).

Candle, Standard. A now obsolete unit for measuring light. The International Standard Candle was of spermaceti wax, burning at the rate of 120 grains of spermaceti per hour. See CANDELA.

Candle-Power or C.P. (See also LUMEN.) Rate of production of light energy. Any light-source producing light at the same rate as one of intensity one candela (*q.v.*), is said to have an output of one candle-power, or 12·56 lumens. The ordinary household gas-filled electric lamp gives approximately one candle-power for every watt of electric power consumed.

Note that candle-power is a *visual* unit. In comparing two light-sources of different colour, the one that appears brightest to the eye is always described as having the higher candle-power, however little it may affect a photographic film. The relationship between candle-power and photographic effect is thus not the same for lights of different spectral composition. (See CANDLE, STANDARD; and ELECTRIC LIGHT.)

Canvas, Printing and making Enlargements on. The following method will enable enlargements to be made on artists' canvas, as a base for painting in oil colours. Wash the prepared canvas with—

Liquid ammonia	10 parts
Methylated spirit	40 parts

When free from grease, dry thoroughly before coating. Make the following:—Soak 7 parts of gelatine in 250 parts of distilled water and dissolve by gentle heat. In the meantime, take 50 parts of fresh albumen and add 125 parts of distilled water, and, when well mixed, add—

Potassium iodide	9 parts
Ammonium bromide	4 parts
Ammonium chloride	1·25 parts

Beat the solution well, stand for an hour, filter through flannel, and add 125 parts of distilled water and the previously prepared gelatine solution. The mixture must be applied to the canvas with a Buckle or Blanchard brush or small sponge. Dry thoroughly, and sensitise as required by distributing the following over the surface with a Blanchard brush:—

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Silver nitrate	20 parts
Glacial acetic acid	10 parts
Distilled water	240 parts

Expose in 75 seconds after sensitising, and give about 60 seconds' exposure with an ordinary negative and bright daylight. (A daylight enlarger is necessary.) Develop with—

Gallic acid	3·5 parts
Lead acetate	0·6 part
Distilled water	250 parts

Apply in the same way as the sensitiser, rinse, and fix in 20 per cent. hypo. (See also SILK, PRINTING ON.)

Cap. The cover used to protect a lens against accidental injury.

Capacitor Flashgun. See FLASHGUN.

Caramel. When ordinary cane-sugar is heated to from 400° to 420° F., the molecule of sugar $C_{12}H_{22}O_{11}$ loses the elements of water, and caramel $C_{12}H_{18}O_9$ is formed. It is highly soluble in water, deliquescent, and has a deep orange-brown colour. It is used in photography in backing plates as a preventive of halation. The preparation of caramel is easy if sugar is heated in a saucepan over a slow fire and with constant stirring, a very little practical experience being sufficient to enable the operator to guard against over-heating and consequent carbonisation of the sugar. (See BACKED PLATES and HALATION.)

Carbolic Acid (Fr., *Acide Phenique;* Ger., *Carbolsäure*). $C_6H_5OH = 94$. Synonyms: Phenic acid, Phenol, Phenylic alcohol, Hydrate of phenyl. A crystalline substance, which is not a true acid, obtained from coal tar by fractional distillation. It is a powerful antiseptic and preservative, for which purpose it is added to gelatine and certain mountants. Solubility: 1 in 20 of water, mixes in all proportions with alcohol and ether.

Carbograph. A printing process which consisted of a specially prepared bromide-of-silver emulsion, incorporated with a pigmented gelatine, such as is used for carbon tissues. By this process direct enlargements and contact prints could be made by artificial light, under conditions similar to those adopted for bromide paper (*q.v.*).

The rationale of the process was briefly as follows :—

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The carbograph paper is exposed, developed and fixed exactly as in making a bromide print, but the image is only partly visible owing to the pigmented gelatine. Next, the image is bleached in a solution containing a chromate ; in this process the chromate is reduced and so tans the gelatine in proportion to the strength of the silver image. The principle is exactly that of Carbro (*q.v.*), and bromoil (*q.v.*). The final image in pigmented gelatine is then developed with hot water as in the carbon and Carbro processes.

Carbon. An elementary body which is met with in many forms ; native as diamond and graphite, also together with hydrogen in the coal deposits. The various forms of coke, retort scale, charcoal, and lamp black are nearly pure carbon. Carbon in this latter form was the original pigment used in carbon printing, and so gave its name to the process.

Carbon Process. Sometimes used as a general term for all processes depending on the action of light on a bichromated colloid, such as gum-bichromate, Artigue's process, and others, but normally used to refer only to printing with pigmented gelatine.

The starting point was a sheet of carbon tissue, which was soft paper bearing a thick coat of soft gelatine heavily impregnated with a pigment. Lamp-black was often used in the heyday of the process, and from that fact the process took its name, but any chemically inert pigment could be used according to the image-colour wanted in the finished print. To sensitize it to light, the carbon tissue was soaked in a solution of bichromate and dried. It was then exposed to daylight under a negative, the exposure being checked by simultaneously exposing the P.O.P. under a second negative of the same density.

The effect of the exposure is to harden the gelatine in proportion to the amount of light received, so that in the shadows a good deal of gelatine is insoluble, while only a little is insoluble in the highlight regions of the picture. This enables the picture to be developed by simply washing away the excess of soluble gelatine with hot water, but there is a difficulty in that the gelatine has been rendered insoluble from the front, so that all the gelatine in contact with the paper base has remained soluble. Simple treatment of the exposed tissue with hot water would wash the whole image off the paper.

This difficulty was overcome by wetting the exposed tissue in cold water and squeegeeing it down to a sheet of strong paper

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coated with gelatine; on putting the sandwich into hot water the gelatine next to the original tissue-paper softened, enabling this paper to be peeled away, and further treatment with hot water revealed the picture. No fixing was necessary, though a few minutes were often given in an alum solution to harden up the image and to clear away any trace of yellow stain from the bichromate.

The picture, of necessity, was reversed from left to right, and where this mattered the " single transfer " process just described was replaced by " double transfer ". For this, the gelatine-coated final-support paper was replaced by a temporary support of smooth waxed paper and development carried on as described; the print was then dried, rewetted, and squeegeed to a sheet of well-soaked gelatine-coated paper. When dry, the temporary support was peeled away, leaving the re-reversed picture on its final support.

Materials for the carbon process, and the related Carbro process (*q.v.*) are no longer obtainable.

Carbon Tetrachloride (Fr. *Tetrachlorure de carbone:* Ger. *Tetrachlorkohlenstoff*) $CCl_4 = 154$. Colourless non-inflammable liquid, density 1·60, boiling at 76° C. Readily dissolves grease, and so is used for cleaning films, the gelatine of which it does not soften. The fumes should not be inhaled, and those using it should not smoke, as any vapour drawn through pipe or cigarette is converted into a poison.

Carbonates. Salts formed by replacing all the oxygen (or hydroxyl groups) of a base by the $''CO_3$ group of carbonic acid. Most metallic carbonates are insoluble, as marble and chalk (both are forms of calcium carbonate), but those of the alkali metals are soluble. Of these the best known are the carbonates of potassium and sodium, the latter of which is washing soda (see SODIUM CARBONATE). Both are partially hydrolysed by water to give sodium (or potassium) hydroxide and carbonic acid. As the alkali is a very strong one, and the acid weak, solutions of these carbonates are markedly alkaline. Sodium carbonate in particular is widely used to supply the necessary alkalinity in developers. Its special value lies in the fact that as some of the freed hydroxide is neutralized, more carbonate hydrolyses, so tending to maintain the alkalinity constant. (See BUFFER.)

Carbro. A carbon process (*q.v.*) by which a print could be made from a bromide enlargement. The enlargement had to be on a non-supercoated paper made specially for this

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process or for bromoil. A sheet of carbon tissue is soaked in a special bleacher, squeegeed down on to the wet print, and the two are left under pressure for a short while. During this time the silver image on the bromide print bleaches, and in doing so creates a chemical that hardens the gelatine. The carbon tissue is then pulled away from the print, and developed exactly as described under CARBON PROCESS, using the single transfer method, which in this case gives an unreversed picture. The bromide print can be redeveloped, but is usually then found to be intensified; nevertheless it was usually possible to make one, or even two, more Carbro prints from it. Alternatively the tissue could be developed on the original print, the latter being either fixed to remove the image, or redeveloped, wholly or partially, to reinforce the carbon image.

The carbon tissue necessary for this process is no longer made.

Carrier. Originally a framework of wood used in the dark slide to enable the operator to use a plate smaller than the full size. The name is now chiefly used for the holder for the negative in an enlarger, and to the sliding frame carrying the lantern slide in an optical projection lantern.

Carte de Visite (or C.D.V.). A once very popular size of the professional portrait, measuring about 4 by $2\frac{1}{2}$ in.

Cartridge. Dry photographic chemicals are often put up in cartridge form for the use of tourists, and home-made cartridges, made to a special size, are often convenient, and may be refilled many times. Roll a sheet of pasted paper round a rod so as to form a tube, and when dry cut to suitable lengths and close with a cork at each end.

The term cartridge has sometimes been applied to roll films in spools.

Cassette. Container in which 35-mm. film, which is used without backing-paper, is put up for daylight loading into the camera. A cassette generally consists of a spool on which the film is wound and a container, of metal or moulded material, which has a narrow exit slot for the film. This slot is light-trapped by a lining of velvet or similar material. In the all-metal cassettes of the Leica and Contax cameras, the spool is surrounded with two concentric cylinders, each with a wide

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slot for the passage of the film. These slots, normally on opposite sides of the spool, are brought together, so opening the cassette, by the action of locking the base of the camera into position after loading. Unless a take-up cassette is used, the film is re-wound into the original cassette for removal from the camera.

The name " cassette " is also applied to special containers designed for X-ray duplitised film technique, the principle being that of the ordinary printing frame. They ensure even pressure over the whole area of the film when intensifying screens are used.

Caustic. A term applied to corrosive or irritant chemicals. Thus silver nitrate is known as lunar caustic, and the caustic alkalies are the hydroxides of the alkaline metals. In optics, the locus of the foci of individual small elements of a lens or mirror suffering from spherical aberration is termed a caustic surface, or, when seen in cross-section, a caustic curve.

Caustic Potash. See POTASSIUM HYDROXIDE.

Caustic Soda. See SODIUM HYDROXIDE.

C.C. Accepted abbreviation for " Cubic centimetre," *q.v.* C.C. has also been used to describe collodiochloride printing-out paper and to indicate " cream crayon "—a special kind of tinted bromide paper.

C.D.V. Abbreviation for Carte de Visite (*q.v.*).

Celluloid. A compact transparent material, the chief constituent of which is pyroxyline or dinitro-cellulose ; camphor being the usual medium (or quasi-solvent) for agglutination. Celluloid dissolved in amyl acetate, acetone, or other suitable solvents, forms a useful varnish.

Cellulose. A substance of formula $C_6H_{10}O_5$, which is the chief constituent of paper, cloth, and wood. Cotton-wool is almost pure cellulose. Treated with a mixture of nitric and sulphuric acids it forms a series of nitro-celluloses ; that in which two atoms of hydrogen are each replaced by the group NO_3 is the soluble pyroxyline used in making collodion and ordinary celluloid (" nitrate base ") for films. For safety base (non-inflammable) films, cellulose acetate is used in place of the nitrate.

Celsius. See CENTIGRADE and THERMOMETRY.

Cement for Leather. See MARINE GLUE.

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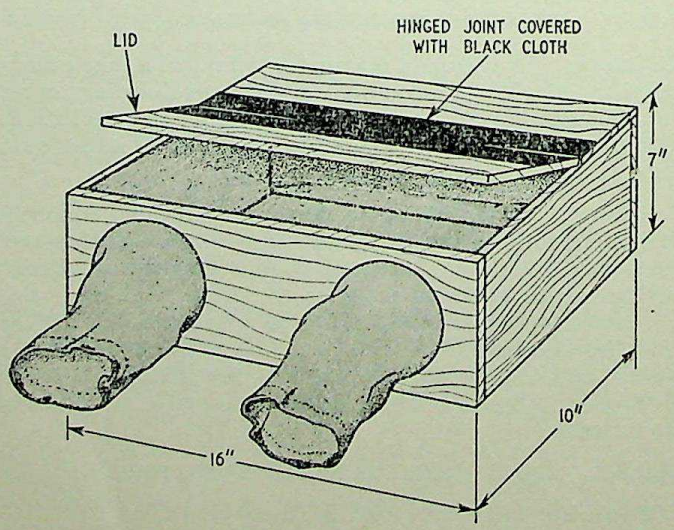
Centi-. Prefix used in the metric system (*q.v.*) to signify 'one hundredth of." A centimetre, for example, is a hundredth of a metre.

Centigrade. Name of a thermometric scale in which the zero is at the melting point of ice, and 100° at the boiling point of water under the standard atmospheric pressure of 760 mm. of mercury. Also known as the Celsius scale. (See THERMOMETRY.)

Ceramic Photography. See ENAMEL AND CERAMIC PHOTOGRAPHS.

Chalk, French (Fr., *Talc;* Ger., *Talk*). A hydrated magnesium silicate; occurs as a fine white powder greasy to the touch. Used for polishing glass surfaces to which wet prints are to be squeegeed for glazing. (See GLAZING PRINTS.)

Changing Bag. The changing bag is a portable light-tight device used for changing plates when no dark-room is available. Generally speaking, the changing bag is made of opaque material with arm-holes, and if in box form it may be called a changing box. Many changing boxes and bags are described in the older books on photography, and the attached sketch shows the general lines upon which a changing-box



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may be made up. A well-fitting light-trap (not shown) round the lid is necessary, and elastic should be fitted round the ends of the sleeves.

Changing Box. A box, generally holding a dozen plates or two dozen cut films, which can be put on the back of a camera in lieu of a dark slide. Means are provided for bringing each plate or film to the front in turn for exposure.
See also CHANGING BAG.

Characteristic Curve. Graph relating the exposure given to an emulsion with the density resulting after development. (See SENSITOMETRY.)

Charger. Alternative term for CASSETTE (*q.v.*).

Chemical Calculations, Reactions, and Equivalent Quantities. See EQUIVALENCE, CHEMICAL; also SOLUTIONS AND SOLUBILITY, and WEIGHTS AND MEASURES.

Chemical Focus. The focus of a lens for blue light, which was the only light affecting the early plates and films. See also CHROMATIC ABERRATION.

Chemical Fog. See FOG.

Chlor-Hydroquinone. See CHLORQUINOL.

Chloride Paper. Term sometimes applied to slow contact printing paper, which usually has a silver chloride emulsion. (See EMULSIONS.)

Chlorides. A chloride is a compound of a metal or other element with chlorine, the most common chloride being sodium chloride, or common salt, NaCl. (See also HYDROCHLORIC ACID.) The so-called chloride of lime contains a hypochlorite as the active constituent.

Chlorobromide Papers. Printing papers coated with a mixed emulsion of silver bromide and silver chloride, and giving on development warm-black or brown-black tones, in place of the neutral black of bromide papers. These papers fall into two fairly distinct categories. The older type, of speed about one-twentieth that of bromide paper, was highly flexible and correspondingly difficult to use to the best advantage. The makers generally issued two or three alternative developer formulæ giving, by direct development, tones of

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different degrees of warmth; in addition, still warmer tones could be obtained by shortening the time of development, by diluting the developer or by adding more bromide to it, or both, and increasing the exposure. By suitable treatment, these papers would give tones of all tints from engraving black to a full red. They are now but little used, and indeed most manufacturers no longer offer them.

The modern chlorobromide papers, on the other hand, are exceedingly popular. They have from half to a quarter of the speed of bromide paper, they are usually developed in an ordinary bromide-paper developer, and they give, with certainty and regularity, prints of a slightly warm-black colour. Many users regard their gradation as superior to that of bromide paper, and all appreciate their very much greater latitude in exposure and development, which allows practically indistinguishable prints to be obtained at any development time from 1½ minutes as a minimum to perhaps 8 minutes as a maximum. Naturally, for prints of the same depth, this allows considerable variation in exposure. Most manufacturers offer the choice of two or more developers, giving slightly different warmth of tone, but in all cases the manipulation is the same, and variation in development time makes little, if any, difference to the tone of the image. The modern chlorobromides are available in several different grades of contrast, though the number of grades offered is not always so great as with bromide paper.

Warmth of tone in a silver image always implies that the image is of fine grain. It is therefore necessary to be a little careful in the fixing of chlorobromide prints, for hypo, and especially the rapid fixers based on ammonium thiosulphate, will slowly attack a silver image, and will do so the more rapidly if it is of fine-grain structure. Prints should never be left in the fixer longer than eight or ten minutes, or in a rapid fixer for more than five.

Another point to watch is that some of these papers are sensitive to green light, and not to blue only as is bromide paper. Care should therefore be taken to use the recommended safelight; one safe with bromide paper, even though this is faster, may cause some degradation of the print through slight fog.

Chlorquinol. 1-2-4 chlorodihydroxybenzene $Cl.C_6H_3(OH)_2$ =144·5. Synonyms: Chlorhydroquinone, Adurol. Developing agent similar in behaviour to hydroquinone (*q.v.*), but rather more active and much less sensitive to low temperature. Except in "lith" type developers (containing formalin) it

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may be substituted for hydroquinone in ratio of molecular weights (144·5 to 110) in any developer in which the latter appears. Its chief application is in warm-tone developers for chlorobromide papers (*q.v.*). (See DEVELOPMENT.)

Chromates. See CHROMIUM, and under the various metals.

Chromatic Aberration. A defect in a lens in consequence of which it brings light of different colours to a focus in different planes. A lens suffering from chromatic aberration may be made to give a sharp image on a non-coloursensitive plate, or by monochromatic light, but cannot do so when photographing normally on panchromatic or good orthochromatic material. (See LENS and FOCAL LENGTH.)

Chrome Alum. See ALUM.

Chromium. A metal most familar to the photographer in the form of plating on cameras, and the compounds of which are much used in the industrial arts. The chromates M'_2CrO_4, and bichromates ($M'_2Cr_2O_7$), when soluble, make gelatine and similar substances highly sensitive to light, the gelatine becoming insoluble. (See CARBON PROCESS, GUM BICHROMATE and ARTIGUE'S PROCESS; also INTENSIFICATION.)

Cinematography is the science of so-called "Moving Pictures." Photography is not essential to cinematography, but is by far the most convenient method of applying its principles.

History.

Cinematography is based on a mental illusion. If, for example, the eye momentarily sees a spot of light in a given position, it is then cut off and succeeded by another spot of light a short distance away, and this process is repeated a number of times in succession in the same direction, and at a sufficiently high frequency, the mind will interpret the series of impressions as the movement of a single spot of light. The process is assisted by the phenomenon known as "persistence of vision," which was familiar to the ancient Greeks. It means briefly that the retina of the eye retains for a short period any impression it receives after the stimulus has been withdrawn. A modern application of the principle occurred in 1825, when Sir John Herschel demonstrated to his friend Charles Babbage that it was possible, by spinning a shilling at a certain speed, to see both sides of the coin at one time. Dr. Fitton, a friend of Mr. Babbage, on being told of the experiment, produced a few days later a round disc of card suspended between two pieces of silk, and having on one side a painting

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of a bird and on the other that of an empty cage. The rapidly rotated disc produced the illusion of a bird inside a cage. At a much later date this invention appeared again as the " Thaumatrope " of Dr. Paris.

Due to the phenomenon of persistence of vision a number of successive but quite distinct images, alternated by periods of darkness, can be presented to the human eye in rapid succession without the observer being aware of variations in brightness. The minimum number of light alternations necessary to avoid " flicker " is 48 per second, which is superimposed on the lesser rate of picture change by some form of shutter which causes each picture to be seen more than once before the next one is presented.

In 1833 W. G. Horner patented the " Wheel of Life," or Zoetrope. A vertical cylinder was pierced with a series of evenly spaced vertical slots. The inside of the cylinder was lined with a long strip of paper bearing a similar number of pictures of a subject in motion. Observation through the slots while the cylinder was rapidly revolved gave the illusion of movement. The earliest pictures were hand drawn.

In 1872 Eadweard James Muybridge, a native of Kingston-on-Thames, made serial photographs of a trotting horse at Sacramento race-track, and later on at the private race-track at Palo Alto of Leland Stanford, Governor of California, who financed the later experiments. Muybridge used 24 cameras in a row, loaded with wet collodion plates, the electro-magnetically controlled shutters being released by 24 threads stretched across the track, and broken by the horse as it ran. He produced similar studies of other animals and of human beings, and later produced a modification of the old Zoetrope, which he called the Zoopraxiscope, for projecting the glass plates on a screen. This instrument possessed the first form of the shutter which is now commonly used for cutting off the light between successive pictures. In 1878 he published the results of his experiments.

In 1881 he lectured in the laboratory of Dr. E. J. Marey of France, who was conducting parallel experiments, and who produced an instrument which took 12 rapidly successive images of a moving object on a circular sensitive plate. Taken from a single viewpoint this represented an advance on the technique of Muybridge.

In 1882 Muybridge, after touring the U.S.A., gave a demonstration of his methods at the Royal Institution.

In 1888 he approached Thomas A. Edison with a view to

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linking the Zoopraxiscope with the Edison phonograph, but the latter was not at that time sufficiently developed.

The year 1888 marked the introduction of long bands of celluloid coated with fast photographic emulsions, as the result of the combined work of George Eastman and the Rev. Hannibal Goodwin. This greatly stimulated research in motion picture work, which was actively conducted by Dr. Marey. W. Friese Greene and M. Evans were using paper film for this purpose in England, and in 1899, they applied for a patent for a machine for taking and projecting moving pictures by means of a ribbon of successive photographs.

Outstanding names of pioneers during this period were Birt Acres, W. Friese Greene and Donisthorpe in England, Edison in America, M. Demeny and Messrs. Lumière in France, and Max S. Kladanowsky in Germany.

The earliest machines were designed to be used mainly as coin-operated peep-shows, but by 1895, that is to say within seven years of the introduction of celluloid for photographic purposes, the bases of cinematography as we know it today had been well established. Since that time there have been enormous developments and improvements in technique, and cinematography has taken its place as a necessary part of modern everyday existence.

We are not here directly concerned with the sound-recording aspect of film, but some details of its history are of interest.

In 1857 Leon Scott in France had recorded sound-waves as a wavy line on smoked paper. In 1877 Edison announced the successful recording of such waves on a cylinder coated with tinfoil, and the reproduction of sound from them. The work of Clerk Maxwell in England, and Alexander Graham Bell in Boston, had greatly extended our knowledge of the nature of sound waves, and of the possibility of transmitting them in the form of electrical energy and reconverting this into sound after transmission. The first experiments had demonstrated the value of the selenium and of the photo-electric cell, which produces a tiny amount of electric energy when excited by light, more or less in proportion to the degree of excitation.

The work of John Ambrose Fleming and Dr. Lee De-Forest had culminated in the production in 1906 of the De-Forest audion, a three-element vacuum tube or valve which provided the means necessary to amplify the sound so far obtained, and gave tremendous stimulus to experiments on sound reproduction. It may be said with truth that most of the basic problems of sound reproduction had already been solved, and

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only the ability to amplify was needed to make practical application possible.

During the period 1922 to 1925 many experiments in talkies were conducted, prominent during this period being the De-Forest Phonofilm and the General Electric Pallophotophone.

In 1926 Warner Brothers and the Vitaphone Corporation presented the first successful talking pictures to the world, using discs.

In 1927 William Fox demonstrated sound photographed on film, and launched the Movietone News Reel. By the year 1928 the sound-film was generally accepted.

There have been elaborations of this method, typical of which is so-called " stereophonic " sound, using a number of sound tracks on the film to feed simultaneously loud-speakers placed at various points around the auditorium. At the time of writing magnetically recorded and reproduced sound is becoming of increased importance and may, in due time, largely supersede the photographic (optical) method of sound reproduction for the commercial film, as it has already done for the amateur cinematographer.

Film and Film Sizes.

Until recently most 35 mm. film was coated on to cellulose nitrate, a highly inflammable material, but all narrow gauge (sub-standard) film was coated on to cellulose acetate, which is slow burning and free from such fire risk. Since approximately 1950 all film, of whatever width, has been coated on to cellulose acetate, slow-burning base.

Film is referred to by its width. 35 mm. is known as " standard " cine film and is mostly used by professionals. In the past wider films have been used, and currently a 70 mm. film is being used to screen films in drive-in cinemas. The sizes below 35 mm. are referred to as substandard or, preferably, narrow-gauge, film. They are 16 mm., 9·5 mm and 8 mm. Originally they were used almost entirely by amateurs, but in the last fifteen years 16 mm. has graduated to professional status. Not only is it used for a considerable amount of research and observation work, but many sponsored films, particularly those in colour, are now made directly in 16 mm., while the majority of documentary and non-theatrical films commissioned by sponsors to be shot on 35 mm. are ultimately reduction-printed to 16 mm., while most of the entertainment

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films produced by the leading companies are also made available to the 16 mm. film libraries.

The following table gives a comparison of the most important dimensions of the sizes of film in most common use.

DIMENSIONS OF FILM SIZES IN COMMON USE

Film width	Number of pictures per linear foot	Camera apertures	Projector apertures
35 mm.	16	22·05 mm. × 16·03 mm.	20·95 mm. × 15·25 mm.
16 mm.	40	10·41 mm. × 7·47 mm.	9·65 mm. × 7·21 mm.
8 mm.	80	4·80 mm. × 3·51 mm.	4·37 mm. × 3·28 mm.
9·5 mm.	40·5	8·50 mm. × 6·5 mm.	8·0 mm. × 6·0 mm.

NOTE: Tolerances are 0·05 mm., except for 8 mm., where they are 0·03 mm.

Types of Sensitive Material.

Cine film may be divided into two main groups:

(*a*) Negative-positive, in which the camera exposure is developed to a negative from which a positive print is afterwards made on to another piece of film that is used for projection.

(*b*) Reversal, in which, by chemical means, a positive image is produced on the film that has been exposed in the camera.

All 35 mm. black-and-white processes and several of the 35 mm. and larger size colour processes such as Technicolor and Eastmancolour are negative-positive. Most of the narrow-gauge processes are reversal, both black-and-white and colour. Negative 16 mm. black-and-white film is obtainable, and many thousands of miles of 16 mm. black-and-white positive film are used, mainly to produce 16 mm. reduction prints from 35 mm. originals. Almost without exception, black-and-white negative material is of the panchromatic, supersensitive panchromatic or ultra-speed panchromatic type, the latter permitting successful exposures to be obtained in quite low levels of lighting. Positive film is non-colour-sensitive, slow and contrasty in character. Black-and-white reversal film is of the panchromatic and supersensitive type, but does not yet include ultra-speed materials.

Colour films are dealt with separately below.

Film must be moved through cameras and projectors and other film machinery with great precision. For this purpose it is pierced at regular intervals down its length with perforations

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whose dimensions and spacing are held within very close tolerances. These perforations engage with the film transport mechanisms on the various machines. Nearly all film intended for use in the camera is perforated down both edges, the two exceptions being in the narrow-gauge sizes. 9·5 mm. film is perforated down the centre of the strip, there being a single row of perforations in the " classic " form of 9·5 mm. and a double row of perforations in the Duplex form. 8-mm. film is perforated along one edge only in its final form as projected, though the double-width film normally used in the camera is perforated along both edges.

In all cine cameras the principle is the same. The film is held in a light-tight storage container of preferred form that permits the camera being loaded and unloaded in daylight. When the camera is operated a toothed sprocket, engaging in the film perforations, withdraws the film from the container and feeds it to the camera picture-gate, which holds the sensitive surface of the film rigidly in the focal plane on which the image is focused. The film is pulled through the gate intermittently by a claw or shuttle, and while it remains stationary, a revolving or oscillating shutter, linked to the film transport mechanism, permits an exposure to be made upon it and then covers the lens as the film is moved to its next position. The film is withdrawn from the picture-gate by a second toothed sprocket and is fed into another light-tight storage container.

The normal professional filming exposures are made at the rate of 24 frames or pictures per second, this frequency having been decided upon, when sound-films were introduced, to satisfy certain requirements of sound recording. In silent days the frequency was 16 f.p.s. The normal speed of projection is 24 f.p.s. If the camera is run more slowly than this, the effect upon projection is to increase the apparent speed of movement, and for the study of such slow-moving phenomena as plant growth, individual exposures may be spaced many hours apart. An illusion of movement may be given to inanimate objects by making individual exposures and modifying or moving the subjects between them. The same principle is used in animated cartoon work where the drawings are altered or exchanged between exposures. If the camera is run more rapidly than 24 f.p.s., projection of the film at normal speed will decrease the apparent speed of movement. This is known as " slow-motion " cinematography and picture-frequencies ranging from fifty to a hundred per second

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up to several hundred thousand per second have been used.

When very high picture-frequencies are required, intermittent transport of the film becomes impossible and the film is caused to travel smoothly past the picture-gate, various means being employed to cause the image to travel down with the film during the time necessary for it to be exposed. One such method is to have a rotating ring of lenses. An elegant one, used mostly with 16 mm. film, is to have a rotating glass block between the camera lens and the travelling film.

Finishing—Negative-Positive Methods.

Negative film is processed by being caused to pass through a succession of tanks or tubes containing the necessary solutions for developing, fixing and washing. Alternatively the various solutions may be applied as a fine spray as the film passes through glass-fronted chambers. After processing the film passes through a drying chamber.

To make a print a roll of processed negative and a roll of unexposed film are loaded into a printer that causes them to pass together past a printing point behind which a light is situated. The intensity of the light can be controlled from moment to moment to accord with the varying densities of the negative. There are two classes of printer:

(*a*) The intermittent, in which the negative and positive, in close contact, are held momentarily in the printing-gate while the exposure is made, and

(*b*) the continuous, in which the pair of films moves smoothly past a narrow, transverse illuminated slit. This form of printer must be used for sound-track and for making "married" prints from a combined negative, *i.e.* where the picture and sound-track are combined together on the same strip of film.

Mass production printers are mostly of contact type, but there also exist optical printers in which the image from the negative film is projected through a lens system on to the positive film separated some distance from it. The two films move intermittently in synchronism but in opposite directions. This method permits the printed image to be larger or smaller than the negative image at will, control of the printing light allows the introduction of fades and similar "effects," while other mechanical controls make it possible to obtain many other complicated effects that, in the earlier days of the cinema, had to be done in the camera. Nowadays

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the cameraman rarely attempts such tricks, nor is his camera equipped for the purpose.

The first prints of a film are obtained from the " master " negative which was exposed in the camera, but for subsequent work it is customary to prepare a fine-grain soft-gradation positive and from this one or more " dupe negatives " from which the main printing of the films for the cinemas is done. This same technique of fine-grain positive and dupe negative is also used to produce optical effects, as well as in any other cases where several generations of copy from the original are required. Positive prints are processed in the same manner as negatives.

Finishing—Reversal Method.

Most narrow-gauge film is processed by the reversal method. The negative is first developed and then the silver image is bleached out. The residual emulsion is then exposed to light and developed to give a final positive image. By this means only one strip of film is used for both camera and projector, and the final positive image is less grainy, as the coarser grains are eliminated when the negative image is bleached out. To compensate for variations in camera exposure various control methods are used, typical being that of Kodak who employ photocell scanning to control the amount of " second exposure " given to the residual emulsion prior to final development of the positive image. This produces a high proportion of usable results, but precludes deliberate departure from optimum conditions to obtain special effects of exposure. The processing companies are, however, always willing to process reversal film without this special control when requested to do so.

All the narrow-gauge colour film processes obtain their first positives by reversal processing, using one of several methods which cause dye images to be formed in direct proportion to the positive silver images in each of the three layers of the integral tri-pack material. (See COLOUR CINEMATOGRAPHY.)

Copies, or dupes, are generally made from reversal originals by printing on to appropriate film which is also processed by the reversal method. Any positive material can be duplicated in this way, but there is always a strong tendency towards increased contrast in the dupe. The method is also used in duplicating from narrow-gauge colour film reversal originals. (See *Colour Cinematography*.) To obtain monochrome duplicates from reversal originals duplicate negatives can be prepared, from which further positive prints are made.

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It is not possible freely to combine all types of original and duplicate in one length of film as, according to the nature of the material, the emulsion may face either towards the screen or away from it during projection, with resultant focusing problems.

A and B roll printing. A method of obtaining opticals which has been particularly applied to reversal duping, especially of colour film, should be mentioned here. In editing a film we proceed to build up two rolls of material, A and B. Starting with A we edit all our first sequences until we come to a point where we require, for instance, a dissolve. On roll B we have, with the aid of a synchroniser, built up precisely the same length of black leader as we have picture on A roll. We splice the first scene of the new sequence on to roll B in such a position that its beginning will overlap the end of the sequence on roll A for as long as we want our dissolve to last. We go right through the film in this way, changing from one roll to the other whenever an "optical" effect is required. Then, in printing, we first run roll A with the duplicating material, fading out for the correct number of frames at the end of sequence one. When we again run the duplicating material with roll B we fade in for the same length of time at the beginning of sequence two. After processing the result will be a perfectly smooth dissolve.

In America the A and B roll method has been used to obtain copies which show no signs of splicing, the change being made from one roll to the other every time there is a splice, care being taken to ensure that the film overlap occurs where it is hidden by the black leader.

Projection.

The picture projector is similar in general principle to the camera inasmuch as film is stored in a coil, is taken from the coil and fed to a picture-gate by means of a toothed sprocket, is held closely in the focal plane by the picture-gate, and remains stationary while a rotating shutter uncovers it and permits light to pass through it to the screen. The film is then moved onwards by an intermittent movement, and is removed from the picture-gate by a second sprocket and is then taken up into another coil. In the majority of 35 mm. projectors the intermittent movement is imparted by means of a sprocket driven by a "maltese cross" or "geneva" movement. In the majority of narrow-gauge projectors a claw movement is employed, similar to that in a camera,

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except that two or more claws may be arranged to operate in tandem.

The long throws and the large screens of the public cinema demand very high light-intensities, and these are provided in most 35 mm. projectors by means of carbon arcs, using either white-flame carbons for monochrome projection, or special colour carbons for colour film projection. Narrow-gauge projectors almost exclusively employ high-intensity gas-filled incandescent electric lamps. Their colour-temperature is much lower than that of the arc lamp, but the various narrow-gauge colour processes are balanced to give correct screen results when used with incandescent lamps. When arc lamps are employed for large-screen 16 mm. colour film projection, special carbons and correcting filters are used. A point to note is that the true light output of a projector is not necessarily proportional to the power of the lamp in it. The only true indications come from measurements made at the screen.

Presentation.

For most of the history of the cinema the picture image on the positive film was approximately four units wide by three units high (1·33 : 1 aspect ratio) and was enlarged by direct projection to give on the screen a picture of the same relative dimensions. Some slight modifications were made when the silent negative and positive images were reduced in size to make room on the film for a sound-track beside the pictures, but the main proportions remained the same and up to the early 1950's the aspect ratio of the projected picture was generally 1·374 : 1. Then, in 1953, the American industry, no doubt in an attempt to combat the growing influence of television on the habits of the cinema-going public, turned its attention to making and showing stereoscopic, or as they called it, 3-D films, using twin cameras and projectors and polarizing spectacles or similar analysers to convey the separate images to the eyes of the spectators.

During the same period successful polarized stereoscopy was being employed in research work using 16 mm. apparatus, and Paillard-Bolex introduced a beam-splitting and polarizing attachment which, placed before a normal 16 mm. camera and projector, recorded two separate images within one 16 mm. frame and then projected them in superposition on the surface of a metallic screen, upon which they could be observed through polarizing spectacles.

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For somewhat obvious reasons true stereoscopic methods proved too cumbersome in the public cinema and were abandoned, but in their place there grew up pseudo-stereoscopic systems, the main characteristics of which were the projection of pictures which were much wider and larger than formerly; these were thrown on to curved screens, the ostensible purpose being to secure closer " audience participation." One ironical result of this is that in small local cinemas that cannot accommodate larger screens, or when projecting narrow-gauge films where the maximum light output of the projector cannot be increased to give a wider picture, the audience actually see a smaller, narrower picture than formerly.

The most ambitious of the pseudo-stereoscopic systems, Cinerama, was introduced as early as 1952 in New York. In this system three cameras are used, running in strict synchronism, and so positioned that their fields of view overlap to record a wide arc of the subject. Similarly placed projectors throw the matched pictures on to three curved screens which between them make one very wide shallow screen partly surrounding the audience. Stereophonic sound is used with this system, speakers being distributed about the auditorium.

This was followed by another pseudo-stereoscopic system, Cinemascope, " the poor man's Cinerama." A normal camera is used in conjunction with an anamorphic lens system, developed by Prof. Chretien, which laterally compresses the image by a factor of 2, the image being recorded within the normal negative area. A similar lens system on the projector expands this squeezed-up image to give a projected picture with an aspect ratio of 2·66 : 1. For practical reasons this ratio has now been reduced to 2·5 : 1. The Todd A-O system is another application of the anamorphic lens.

The projection of enlarged pictures called for more light and also created demands for higher definition. To deal with the latter VistaVision was introduced in 1954. In this system normal 35 mm. film moves through the camera in a horizontal direction, each image being 2½ times the size of the image on 35 mm. film that has been exposed in a normal camera. When first introduced the VistaVision print was reduction-printed on to normal 35 mm. film and projected on an orthodox projector. During 1955, however, Paramount introduced for VistaVision a projector that runs the film horizontally as in the camera, and projects from a positive image the same size as the image on the original negative.

All these pseudo-stereoscopic, wide-screen processes employ

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screens that are curved to a greater or less degree. During the first period following the introduction of these various systems there was considerable confusion regarding the aspect-ratios of projected pictures, these varying from as little as 1·33 : 1 up to 2 : 1. Some preference is shown for 1·85 : 1, but there are many problems of existing theatre architecture as well as purely technical and optical considerations.

In narrow-gauge presentation the 1·33 : 1 ratio has been generally adhered to, but in 1955 Bell & Howell Company, U.S.A., introduced an anamorphic system for 16 mm. cameras and projectors, under the name "Filmorama," giving a 2·68 : 1 aspect-ratio on projection.

Characteristically, Pathéscope have approached the problem in a way which differs entirely from everybody else and which is designed for extreme economy. "Classic" 9·5 mm. film, which has a single row of perforations down the centre, registers a frame image measuring approximately 8·4 mm. × 6·5 mm., the film running vertically in camera and projector. "Duplex" film, which has a double row of perforations running down the film at some distance from the edge, and which must be used in a special camera and special projector, will give the same sized picture as "classic" 9·5 mm. when the film is run vertically. But by manipulating a special mask and turning the camera on its side, so that the film runs horizontally, pictures can be recorded down one side of the film only. The second side of the film is exposed after the film charger has been inverted in the camera, and the processed film, slit down the centre and then joined end to end, is projected horizontally to give a wide-screen type of picture from a film image measuring 6·5 mm. × 4·2 mm.

The most extreme form of presentation is Circarama, which, at the time of writing, has only been employed in narrow gauge. Eleven 16 mm. cameras between them cover a circular field of vision of 360 degrees, and the resultant pictures are thrown on to eleven screens which face inwards to form a large annular screen completely encircling the audience.

Sound Reproduction.

Whereas the film moves intermittently through the picture-gate, it is essential that the sound track should move past the recording and reproducing sound-heads continuously at a speed which is held constant within very narrow limits. In practice, sound is registered on a separate strip of film in a "sound camera." The sound is recorded by (*a*) the variable

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density method, by means of which varying intensities of light passing through a slit imprint a series of transverse bars of differing width and density across the track or (*b*) the variable area method, in which moving masks or other devices cause the proportion of fully exposed to completely unexposed film across the width of the track to vary from moment to moment.

The picture-film and the sound-film are edited separately and matched together so that they are in correct synchronism, and then a married print is made in which the sound-track runs down one side of the film alongside the pictures, but in which the sound-record is ahead of the corresponding visual material, to allow for the fact that picture-gate and sound-head are spaced apart in the projector. In the projector the sound-track moves smoothly past a slit in the sound-head, an exciter-lamp shining through the track and slit on to a sensitive photocell, the varying densities or areas on the track modulating the amount of light which passes to the cell from moment to moment. The tiny current thus generated is passed through an amplifying network, and is finally used to operate a system of loud-speakers. Generally the loud-speakers are placed behind the screen, which is perforated to allow the sound to emerge more easily. When a solid screen is used, as for instance when projecting narrow-gauge film in a place not primarily designed as a cinema, it is preferable that the speaker be placed above or fairly high up alongside the screen.

The best sound reproduction is given by photographic silver-image tracks. Dye sound-tracks, such as those on the narrow-gauge reversal-type colour films, are never so satisfactory, as the dyes do not exercise the same degree of control on the beam from the exciter-lamp to the photo-electric cell, although considerable improvements have been obtained in recent years. It is largely for this reason, however, that magnetically recorded sound is tending to take the place of the photographic track on narrow-gauge colour films, and a number of projectors embody means for reproducing sound from photographic or magnetic tracks at will. Some of them also have means for recording magnetic sound on the projector.

The magnetic track is coated on to the film, either to cover the whole of the existing photographic track, or down one half of it only, or two narrow tracks may be coated down the two film edges, depending on the system adopted. There are also several systems for running separate magnetic tape at the same time as the picture-film, but there are still grave synchronization problems owing to the nature of the tape

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itself and the means used to drive it. The best results have been obtained either from perforated tape or from tape upon which a pulse is recorded at the same time as the main sound-record is made, and is then used to lock the tape into synchronism on replay. Magnetic sound is of particular interest to the users of the two narrowest gauges, 9·5 mm. and 8 mm., as it has brought facilities hitherto denied to them.

Colour Cinematography.

(See also COLOUR PHOTOGRAPHY.)

Space does not permit of a complete survey of all colour systems, and only a few typical methods can be referred to.

The association of movement with colour has presented a peculiarly difficult problem, both in the initial analysis of the subject into colour components, and then in the making of the final prints. One of the earliest methods consisted of making exposures in quick succession either through normal three-colour filters or through two-colour filters designed to cover the whole spectrum, and afterwards projecting the positive pictures in the same sequence through matching three- or two-colour filters. One of the outstanding disadvantages of these methods was the presence of colour fringes due to the displacement of the subject between successive exposures. Fairly successful results have been obtained by taking two-colour separation negatives simultaneously by means of a beam-splitting device which diverted the incident rays in two directions, past colour filters to separate strips of negative material. Prints from these were made in two colours complementary to those of the taking filters, and were combined in some preferred manner. The bi-pack method has also been used. Two films are run through the camera in close juxtaposition, and by selective sensitizing of the two films and the interposition of a filter layer between them, the two halves of the spectrum have been recorded separately but simultaneously with some measure of success.

Nowadays it is generally agreed that three-colour analysis and synthesis are essential for a successful colour picture.

Optical process. An interesting optical process, which was used for 16 mm. film under the trade name of Kodacolor, was the Keller-Dorian process. A tripartite filter in the three primary colours red, green and blue was placed in juxtaposition with the taking lens. The panchromatic film was placed in the camera with its transparent base facing towards the lens,

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the outer surface of this base being embossed with tiny cylindrical lens-elements running parallel with the length of the film. When the film was exposed the main camera lens "drew" the picture, but the lens-elements on the film base superimposed on this individual images of the tripartite filter, making the local colour-selection. The monochrome positive was projected with its base towards the screen with a similar tripartite filter in front of the projection lens. The monochrome images modulated the transmissions of the three filter colours and a colour picture appeared on the screen. Attempts were made to use this process also in the professional field.

All subsequent important processes have made use of filter dyes incorporated in the projection print in some preferred manner, in accordance with either the additive or the subtractive manner.

Additive method. The chief example of this method was Dufaycolor. The film incorporated a pattern or *réseau* of filters, in the three primary colours, between the base and a panchromatic emulsion, and the film was exposed in the camera with the base facing towards the lens so that exposure was made through the filter pattern. Narrow-gauge Dufaycolor was processed by the reversal method. 35 mm. Dufaycolor was developed as a negative and thereafter printed on to Dufaycolor positive film which also embodied a *réseau*. Special precautions had to be observed in making prints to avoid interference patterns or "*moiré*" in the final prints. The process when at its best gave great accuracy of colour, but there was excessive loss of transparency as compared with monochrome or subtractive colour methods.

Subtractive methods. One of the most important is Technicolor. Starting as two-colour, it is now operated as a three-colour process, the three colour negatives being obtained by a combination of beam-splitting and bi-pack methods. A gelatine relief image, known as a matrix, is prepared from each negative. The matrix is impregnated with a dye of colour complementary to the original colour sensitivity, and this colour is off-set by imbibition methods on to a strip of film carrying a suitable transparent coating. The three colour images are combined in this way and the matrices can be used many times. Sometimes a grey key image is also included. A wide range of control can be exercised by varying the hue and saturation of the printing colours used.

The other most important application of the subtractive principle is in the form of integral tri-pack material. First

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introduced for narrow-gauge film, and appearing in various forms under such names as Agfacolor and Kodachrome, it now fills an important role in the 35 mm. professional field in such processes as Eastmancolor. One of the outstanding advantages of this method is that the film can be used in a normal cine camera without the need for any modification.

Integral tri-pack film consists of three layers of emulsion coated one above the other on a transparent base, with suitable interlayers of gelatine, either clear or containing filter dyes. The layers are so sensitized that each is selectively responsive to one of the colour primaries, red, green and blue-violet. When the film is reversal processed after exposure, dye-coupling development is used for the positive image. The dye-coupler may be introduced during processing or may be held within the emulsion layers until a suitable developer is used to activate it. When the positive silver images have been dissolved away, the colour picture is composed of three dye layers in terms of the subtractive colour primaries, cyan, magenta and yellow.

In the Eastmancolor process the camera material contains dye couplers which permit it to be developed to give a colour negative. In such a negative a red coat will appear cyan, a grass plot will be magenta, and a blue sky will be yellow. A print can be made from this on to Eastmancolor tri-pack positive stock, or steps can be taken to obtain three colour-separation negatives that can be printed by an imbibition process, such as Technicolor, since this offers better control and lower cost when large editions of a film are required.

Ferraniacolor is also an integral tri-pack film containing dye couplers. In 35 mm. form it is developed as negative and printed on to tri-pack positive stock. In narrow gauge sizes it is reversal processed, and there is also 35 mm. reversal duplicating stock.

Duplication of colour film. The dyes used in colour film are necessarily imperfect and absorb some of the colours they should transmit. Consequently colour duplicates from an original tend to exhibit dilution and falsification of the colours. This can be overcome to some extent by interposing a negative of low gamma between the original and the material on to which it is to be copied. This method is known as masking, and masked prints have superior qualities of definition, contrast and colour as compared with unmasked prints. In the Eastmancolor material, masking is achieved automatically by including coloured dye-couplers in the negative material,

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so that each negative dye-image is accompanied by a matching low-gamma positive image in a colour that will combine with the negative image so that the unwanted light absorption over the whole picture area is constant, and can therefore be corrected by the use of appropriate filters when making prints from the negative. Special inter-negative material has also been developed for Eastmancolor, the narrow transmissions of the dyes assisting in obtaining the highest quality prints with the minimum of control techniques.

Amateur Cinematography.

The present-day amateur cine movement may be said to date from the introduction of 16 mm. and 9·5 mm. reversal film stock. Before that time attempts had been made to interest the amateur in moving pictures on 35 mm., 17½ mm. (half standard), and 28 mm. wide. The latter size, introduced by Pathéscope and Victor, was for projection only. 17½ mm. was ordinary standard film slit down the centre.

In 1923 Kodak introduced 16 mm. Kodak reversal film, together with the Cine-Kodak Model A camera, and the Kodascope projector, while almost simultaneously there appeared the 16 mm. Bell & Howell Filmo camera and the Victor 16 mm. camera. These cameras employed daylight-loading spools of film and were driven by a clockwork motor; they were typical of the majority of narrow-gauge cine cameras. The charger film-loading principle was first adopted for 16 mm. cameras by Siemens about 1930 and in 1934 Kodak introduced the Magazine Cine-Kodak. The principle is the same in both cases. The cassette, magazine or charger embodies the continuous transport mechanism for the film and engages with the camera drive when loaded. The intermittent claw is part of the camera proper. The film drops into place in the camera gate when the charger or magazine is placed in the camera. The advantages of the method are very rapid loading and the ability to open the camera without fogging more than a very small part of the sensitive material. In the Kodak Magazine a sliding shutter obviates all fogging when the camera is opened.

9·5 mm. reversal film started about the same time as 16 mm., being introduced by Pathé of France (now Pathéscope Ltd.) together with the Pathé Baby camera and Home Cine Projector. Most 9·5 mm. cameras are loaded by means of chargers or cassettes, but one or two advanced instruments use daylight loading spools.

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The standard 9·5 mm. film is centrally perforated, there being 40 perforations per foot. These fall between adjacent frames. In 1955 Pathé introduced their Duplex film, which differs from standard 9·5 film only by having two perforations side by side, instead of only one, between frames. Besides serving all the purposes of the standard 9·5 mm. film, it can be used, with the camera held so that the film runs horizontally, for a half-size picture of " wide screen " shape (6·5 × 4·25 mm.; aspect ratio 1·53 : 1). The film is run through the camera twice, and after processing is slit and joined end to end. The half-width film is referred to as " Monoplex."

8 mm. film was introduced in 1932, when Kodak put out the Cine-Kodak 8 camera, projector and film. Since then a large number of instruments and several brands of film have been introduced. In one form 8 mm. sensitive material is supplied in strips 16 mm. wide, but with 80 perforations per foot down each side of the strip. The film is run through the camera and exposed down one side only, then turned round and exposed down the second side. After processing it is split longitudinally and joined end to end. Some cameras, notably the Movex 8, use film that is only 8 mm. wide.

Narrow-gauge Cinematography—A Conclusion.

Narrow-gauge film was originally introduced to provide a hobby for the amateur. Its possibilities have now been recognized in many directions and it is employed for many professional and semi-professional processes. Recognition of 16 mm. was accelerated during the Second World War, when many millions of feet were projected as a means of entertainment, instruction and education for the armed and civilian forces. It is now recognized as an indispensable tool for the educationist and is also employed by both propagandists and advertisers.

On the taking side, narrow-gauge film has been recognized by doctors, scientists and others as a valuable tool for record, research and training. It has an important function as a watching instrument where it would be undesirable or uneconomic to employ human observers. It is playing an important part in the examination of high-speed phenomena. Taking advantage of the small size, weight and inertia of narrow-gauge film, technicians have evolved cameras capable of recording up to 3,000 exposures per second in the 16 mm. size and up to 6,000 per second in the 8 mm. size. Because of its smaller bulk the narrow-gauge camera has been found most

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convenient to use in cine-photomicrography, in under-water research and a number of kindred activities.

All the three principal sizes of narrow-gauge film, 8 mm., 9·5 mm. and 16 mm., have the advantage of integral tri-pack colour systems. The value of this has been recognized in surgery and medicine, and commercial and technical users, technicians and educationists and many others are all freely employing narrow-gauge colour film for their various purposes.

16 mm. film has long had the advantage of married prints for sound-film projection, the film for this purpose being perforated down one edge only, the track lying down the unperforated edge. Attempts were made to provide photographic (optical) sound for the other two edges, but with limited success. Now the advent of magnetically recorded and reproduced sound has profoundly changed the situation, especially for amateurs.

A ferric oxide strip can be coated down the length of an existing film, and as only a very narrow strip is needed, this facility can be applied to all three sizes of narrow gauge film. 16 mm. enjoys some slight advantages, inasmuch as the oxide strip can be coated down the full width of an existing optical sound track, or down only half its width so that magnetic or optical tracks may be made use of at will, or, with double perforated 16 mm., two narrow tracks can be coated down the edges of the film. Already there are several projectors which will reproduce sound from magnetic tracks, projectors that will reproduce either magnetic or optical tracks, and projectors that will enable the user to record as well as reproduce sound. There are also magnetic sound-reproducer attachments which are linked to existing sound or silent projectors.

One of the outstanding advantages of this new system is the very high sound-quality that can be obtained from all forms of magnetic track.

Circle of Confusion. The image formed by the lens of a point of light—*e.g.*, a star—is never quite a mathematical point, as it would be with an absolutely perfect lens, but is instead a tiny disc of light. This disc, or its diameter, is called the circle of confusion. The smaller the disc, the more perfectly corrected is the lens.

The same term arises in discussing depth of focus (*q.v.*), in connection with which it is necessary to decide how far the image may depart from theoretical sharpness before appearing unsharp to the eye. The permitted departure from absolute

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sharpness is expressed by stating the diameter of the disc that can be permitted to do duty for the theoretical point. It is usually assumed that a circle of confusion of $\frac{1}{100}$ in. corresponds to the boundary between "sharp" and "unsharp" in a print held at the normal viewing distance of about 10 in. from the eye.

(See DEPTH OF FOCUS and HYPERFOCAL DISTANCE.)

Circle of Least Confusion. If a pencil of light from a point source, after passing through a lens, does not converge to an absolute point before diverging again, the circle of least confusion is the diameter of the pencil at its narrowest. (See *Astigmatism* under LENS.)

Clayden Effect. If an emulsion is given a very short exposure ($\frac{1}{1000}$th. sec. or less) to a very intense light, it is partially desensitized, so that on subsequent exposure the part affected by the first exposure does not darken. This gives a form of reversal, and explains why lightning or electric sparks are sometimes shown as black on a print.

Clear-Spot Focusing. See *Aids to Focusing* under FOCUSING SCREEN.

Clips. The wooden spring clips sold at oil shops can be made much less liable to injure prepared papers and prints if the gripping ends are dipped in melted paraffin wax. The gripping ends of metal clips may be dipped in the sensitive bitumen varnish mentioned on another page (see ASPHALT PROCESS). The coating becomes gradually hardened and increasingly protective by exposure to light. Special clips for holding prints or films when hung up to dry are supplied by most photographic dealers.

Cloud Negatives. At one time every enthusiastic photographer provided himself with a series of negatives of clouds, and these he would combine, by combination printing, with those of his landscapes that showed a "bald" sky. Modern emulsions are so much more colour-sensitive that clouds can now usually be rendered reasonably satisfactorily, if any are present, and the practice of making separate cloud negatives has to a large extent fallen into disuse. Nevertheless occasions remain where clouds can with advantage be added to a picture, and if the photographer has a small stock of cloud negatives on which to draw he will always be in a position to make the necessary improvement in his picture.

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Cloud negatives can be taken successfully on any film, with or without a filter as circumstances suggest. The negatives should not be too contrasty, and except for special effects the clouds chosen to photograph should not be too dramatic. The exposure required is roughly one-tenth of that which would be given to the landscape as a whole.

Thin light clouds against a blue sky are liable to be lost, or at least to stand out insufficiently well, unless a pale yellow filter is used to hold back the blue of the sky. With a deeper filter the differentiation is greater, and the clouds can be made to photograph as though more prominent than they actually were. A red filter will bring out the blue of the sky as practically black on a clear day, but if the sky is the hazy blue-white so commonly seen in England, a red filter may be needed to darken it sufficiently.

Where the sky is entirely covered by clouds, a filter does not help, and reliance must be placed entirely on correct exposure and development to separate the tones of grey.

In all cases it is a wise precaution to include the horizon on the negative as a means of telling how high the clouds were in the sky. Nothing is more unsatisfactory than a print showing, near the horizon, cloud-formations characteristic of the zenith.

Clouds, Printing in. See COMBINATION PRINTING.

Coated Lenses. Lenses in which the surfaces of the various component glasses have been coated with a thin film, usually of silica or evaporated fluorite, to eliminate reflections. Complete prevention of reflection can only be brought about for light of one wavelength striking the surface at one particular angle, but nevertheless the reduction practically obtainable is very great. In a lens of four air-spaced components the total loss of light by reflection is about 35 to 40 per cent. of the total, and some at least of the light reflected reaches the film as scattered light, degrading the shadows and reducing contrast. By coating the lens this loss can be reduced to about 5 per cent., noticeably increasing the effective speed of the lens. With a coated lens at *f*/5·6, the exposure need hardly be more than that needed with an uncoated lens at *f*/4·5.

Even more important is the elimination of scattered light; the coated lens gives more overall contrast and markedly better shadow-rendering, leading to a print of much richer quality. (See also ENLARGING.)

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Cold-weather Photography. During the winter months certain precautions have to be taken with regard to the temperatures of the different solutions used if normal results are to be obtained. Particularly does this apply to the process of development.

All chemical processes proceed more slowly at low temperatures than at high. If the developer is cold, development will in consequence take longer. This fact is allowed for in the "time and temperature" tables issued for many developers (see DEVELOPMENT), but it must not be taken for granted that, even with the necessary prolongation of time, the resulting negative will be the same as if it had been developed at a more normal temperature. The behaviour of mixed developers such as M.Q. is liable to distinct alteration on account of the different temperature-coefficients of the two developing agents involved. A further difference is that a negative or print developed at a low temperature is liable to show signs of under-exposure that would have been absent if development had taken place at 65° to 68°F. The converse is also true, and it has long been accepted that for the development of under-exposed plates the developer should be as warm as the gelatine will stand.

For normal work in cold weather the developer should be warmed to 68° F. by standing the vessel containing it in a larger vessel of warm water. Dishes, measures and the tank should also be warmed by filling them with warm water, and the hypo bath should be brought to a temperature not much lower than that of the developer.

The temperature of the dark-room should also receive attention, as if it is too cold not only is it rendered unpleasant to work there, but solutions, even if warmed to the correct temperature, will cool down again before their work is done. An electric fire so placed that no direct light from it can reach the sensitive material, a gas fire with a small screen before it, or an oil heating lamp, are all reasonably safe when working with even the fastest bromide paper. In negative making they should be turned out during the time, usually only brief, that the plates or films are exposed to any light there may be in the room. (See also TEMPERATURE COEFFICIENT.)

Collodio-Chloride Printing-Out Paper. This was proposed by Wharton Simpson in 1865, and for some considerable time collodio-chloride was a very popular printing process. It was a variety of P.O.P. (*q.v.*; see also GELATINO-CHLORIDE

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PAPER), in which collodion took the place of gelatine. As plain P.O.P. it has not been made since 1914, but persisted for many years longer in self-toning form. (See SELF-TONING PAPER.)

Collodion. The vehicle used in wet-plate processes for holding the haloid salts necessary for the formation of the sensitive film. It is prepared by dissolving pyroxyline (*q.v.*) in a mixture of equal parts of alcohol and ether, and it is a transparent glutinous liquid, which, when poured upon any surface, leaves, by the evaporation of the solvents, a highly transparent and structureless film of pyroxyline. A special kind of collodion, called enamel or leather collodion, has sometimes been used for enamelling prints (*q.v.*).

Collodion Processes. A short account of the wet collodion process will be found under the heading WET COLLODION PROCESS, but this method is now scarcely used excepting in connection with negatives for photo-mechanical processes. The reader is referred to the standard books on the subject—"Wet Collodion Photography," by C. W. Gamble; "The Wet Collodion Process," by Arthur Payne; and "Collodion Emulsions," by Henry Oscar Klein.

Colloids. Non-crystalline substances which do not diffuse through a porous membrane. Those of photographic interest include albumen, gelatine, cellulose, dextrine, starch, tannin, and caramel.

Collotype. See PHOTO-MECHANICAL PRINTING PROCESSES.

Colour Coefficient. The photographic image on a negative may be pure black, or it may be coloured. If the colour is non-actinic with respect to the printing paper used, the print obtained will be more contrasty than one from an untinted, but otherwise identical, negative. The ratio of the gamma (*q.v.*), of the coloured negative, as determined from the print made from it, to the gamma of an otherwise identical untinted negative, is termed the colour-coefficient, or the colour-coefficient of contrast. For yellowish or brownish images it is normally greater than unity; for a negative toned blue it is less than unity.

Variation of the colour-coefficient can be made use of in practical work, when negatives are toned brown or red to increase contrast (see INTENSIFICATION) or are toned blue to reduce it. (See REDUCTION OF DENSITY).

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Colour Developing Agents

Colour Developing Agents. Colour development is based on the reduction to metallic silver of a latent image by an organic developing agent which is oxidised in proportion to the reduction achieved. These oxidation products unite with a colour former to give a dye, which is produced image-wise. Most colour developing agents belong to the dialkyl-p-phenylenediamine family of which diethyl-p-phenylenediamine is the best-known member. The table below lists the most common agents in use at the present time:

Names	*Formula*	*Trade Names*
Diethyl-paraphenylene-diamine sulphite or SO_2 compound of p-diethylamino-aniline.	$(C_2H_5)_2N\text{-}C_6H_4\text{-}NH_2\cdot SO_2$	Genochrome Activol
Diethyl-paraphenylene-diamine hydrochloride or HCl compound of p-diethylamino-aniline.	$(C_2H_5)_2N\text{-}C_6H_4\text{-}NH_2\cdot HCl$	Activol H
Diethyl-paraphenylene-diamine sulphate or sulphate of p-diethyl-amino-aniline.	$(C_2H_5)_2N\text{-}C_6H_4\text{-}NH_2\cdot \frac{1}{2}H_2SO_4$	Activol S
Ethyl-ethyl-hydroxy-paraphenylene-diamine sulphate or 4-amino-N-(β-hydroxyethyl) ethylaniline sulphate.	$C_2H_4OH\cdot C_2H_5\cdot N\text{-}C_6H_4\text{—}NH_2\cdot \frac{1}{2}H_2SO_4$	Droxychrome Activol X
2-amino-5-diethylamino-toluene hydrochloride or HCl compound of diethyl-p-toluylene diamine.	$(C_2H_5)_2N\cdot C_6H_3\cdot CH_3\cdot NH_2\cdot HCl$	Tolochrome CD2
4-amino-N-ethyl-N(β-methane-sulphon-amido-ethyl) m-toluidine sesquisulphate monohydrate.	$CH_3SO_2NH\cdot C_2H_4\cdot C_2H_5\cdot N\cdot C_6H_3CH_3\cdot NH_2\cdot 1\frac{1}{2}H_2SO_4\cdot H_2O$	Mydochrome CD3

Colour Photography. The earliest approach to the problem of the reproduction of natural colours by photography

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took the form of attempts to find a substance that, when exposed to light, would take on the colour of the light falling on it. Some hint of the possibility of this was found in the fact that many of the early daguerreotype workers reported that, on occasion, a suggestion of the natural colours was seen in daguerreotypes when these were inspected at an appropriate angle. Otto Wiener suggested that the colours in question were due to the formation of stationary waves in the image layer as a result of reflection at the underlying polished surface.

In 1891 Professor Gabriel Lippmann succeeded in obtaining colour pictures by a process working on this principle. He found that if a transparent grainless layer of silver halide was backed up by a pool of mercury and exposed in a camera, the light reflected back from the surface of the mercury interfered with incoming light to give stationary waves which were recorded in the sensitive layer as a series of laminae in the form of alternating layers of silver and clear gelatine. When such a plate is viewed at an appropriate angle by reflected white light, all rays in the white light are absorbed save those whose wavelengths correspond with the spacing of the laminae. These are reflected, so reproducing the original colours.

The Lippmann process can claim to be the only direct method of colour photography that has ever been carried to a practical stage. Nevertheless, prolonged exposures, complicated apparatus, delicate manipulation, specialised material, and a final result which can only be seen when viewed in an inconvenient manner all combine to make the process, interesting as it is, quite valueless commercially.

The Bleach-out Process.

A different approach to the problem of recording colour by the direct action of light depends on the fact, known since 1842, that if a dye is bleached by light the bleaching is brought about by light of colour roughly complementary to that of the dye—that is, by light which it absorbs. Using the principles underlying the three-colour subtractive processes (see later in this article) Dr. H. J. Smith in 1906 coated a paper with a mixture of three light-sensitive dyes, and used it for making direct positive prints from a positive colour transparency. This Uto paper was a black material, necessarily too insensitive to be used in the camera, but if exposed to bright daylight under a coloured design—stained glass, for example—a very creditable reproduction of the colours was obtained. No means of fixing these prints was found, however,

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and they had to be kept in the dark to prevent further bleaching of the colours by light.

Three-Colour Processes.

All modern colour processes are based, not on reproducing the colours of the original subject, but on providing an imitation that, though possibly profoundly different if spectroscopically examined, appears to the eye as an exact match of the original colour. This is made possible by the fact that, as suggested by Young in 1807 and proved experimentally by Clerk Maxwell in 1855, all colour perception is the result of three fundamental colour-sensations, singly or combined in various proportions. If, therefore, a spectrally pure monochromatic colour, consisting of light of one extremely restricted range of wavelengths, stimulates all three of the colour-perceiving elements of the eye in a certain proportion, all that is necessary to reproduce that colour with complete perfection, so far as the eye is concerned, is to reproduce the stimuli it causes. This can be done by mixing, in the right proportions, three lights each of which separately affects one of the three colour-sensitive elements of the eye, and it may even happen that none of these three lights includes the spectrum colour that their combination appears so precisely to duplicate.

Additive Methods.

The simplest approach to the problem of reproducing a colour is by seeking to provide each of the colour-sensitive elements of the eye with its own separate stimulus. That this procedure will work was demonstrated by Clerk Maxwell, when he showed that by projecting three separate circles of coloured light, one blue, one green, and one red, white light was produced at a point where they all overlapped. Further, yellow was seen when the red and green circles overlapped, magenta was formed by adding red to blue, and cyan-blue (blue-green) when blue was added to green. The tints of these composite colours could be varied over a wide range by altering the relative proportions of the constituent lights.

If a coloured object is photographed three times, using in turn red, green and blue filters, each plate will bear a record of the amount of one of these three primary colours present in the subject. If a positive is made from each negative, and these are projected in register, each from a separate lantern, and if further each positive is illuminated by light of the colour

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by which its negative was taken, the picture seen on the screen will be in full colour.

Though the results given by this procedure can be as nearly perfect as those by any colour process yet developed, there are obvious difficulties and inconveniences. The same effect can be produced by making all three records on one plate through colour filters of microscopic size intermingled in close juxtaposition, each being too small to be seen individually. This is the basis of all the mosaic screen, or " screen-plate," processes.

Their method of working is simple. If an object reflecting only pure red light is photographed, the plate is unaffected behind the blue and green elements, which absorb red light, but developable behind the red elements of the mosaic or " réseau." On development and subsequent reversal to a positive, each of the blue and green elements is blacked out by a deposit of silver, but behind the red elements there is no deposit. On looking through the plate, the only colour seen is red.

If the colour photographed is more complex, involving all three colour-elements of the plate for its duplication, varying degrees of opacity are produced behind the three sets of colour-screens, so that in viewing appropriate proportions of the total light are allowed to pass each. These, blended by the eye, reproduce the original colour.

Commercial Screen-Plate Processes.

The Lumière Autochrome, the first commercially successful additive screen plate, and now obsolete, was typical of such systems. Three equal portions of potato-starch grains were dyed respectively red, green and blue-violet. The dyed grains were then mixed together and the mixture dusted on a glass plate covered with a tacky coating. The surplus grains were dusted off and those adhering to the glass flattened out under great pressure, producing a mosaic of microscopic colour filters. Upon this mosaic a panchromatic emulsion was coated, and the resulting plate exposed in the camera with the mosaic towards the lens, and reversed to a natural colour transparency in the usual manner.

An exposure of approximately $\frac{1}{25}$ of a second was required at *f*/1·9 in midsummer sunlight. This plate was considered by many to be the most satisfactory screen-plate from the point of colour rendering. It was withdrawn from the market in 1937 and replaced by " Lumicolor "—the same type of réseau

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coated on sheet film, and by " Filmcolor "—a roll film version. The former required a lens filter in addition.

The Agfa screen-plate also had an irregular mosaic made up of grains of coloured resin, applied to the glass plate in a manner similar to that used for the Autochrome plate, and in practice required rather less exposure.

The mosaic in the Dufaycolor film was made by printing a greasy ink resist on a blue-dyed cellulose-ester base, and first bleaching and then dyeing the interspaces green. The lithographic printing of the greasy resist was then repeated at an angle, followed by bleaching of the interspaces and dyeing them red. This produced a geometrical mosaic of blue and green squares separated by red lines—roughly one million colour elements to the square inch.

The Finlay plate, recently revived by Johnsons' as the Johnson-Finlay screen plate, but not continued, also had a geometrical mosaic, the individual elements being, however, of larger size than the Dufaycolor. It had the advantage that the mosaic colour screen was independent of the actual photographic negative. After the latter was developed, any number of colour positives could be made from the negative by the normal methods of lantern slide making—each monochrome positive being bound up in register with a mosaic colour screen for viewing.

No screen-plate material is now made, the additive processes having now been entirely superseded by subtractive processes.

Subtractive Transparencies.

While the screen-plate processes have proved very popular, and had the great advantage of simplicity in processing, they had their disadvantages too. Firstly, the screen or réseau had to be made up of discrete elements which came visible, as grain or pattern, on enlarging, and secondly, the transparencies produced absorbed a good deal of light. Even assuming perfect dyes, they must absorb at least two-thirds of the spectrum even at a point in the picture that is nominally " white " (no silver deposit). An average good transparency absorbed between 70 per cent. and 80 per cent. of light, calling for very high-power projection lamps if large pictures were to be shown.

More transparent pictures, free from réseau pattern, can be had by subtractive methods. Instead of starting with darkness, and the building up of three independent colour-stimuli, one for each of the colour-sensitive elements of the

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eye, a subtractive process starts with full white light, affecting all three elements to the full. Each of the three stimuli is then cut down to the required level by interposing the right amount of a dye—one for each colour—between the eye and the source of white light.

A little consideration will show that for this process to work three requirements have to be satisfied. Firstly, three dyes are needed such that each absorbs one of the three fundamental colours—blue, green and red—to which the eye is sensitive, passing the other two. Secondly, three superposed layers, one of each dye, will be needed. And thirdly, variations in the depth of tint of each dye will be required to give the many colours of a natural object; that is, the actual images, one to each layer, will have to be made of dye. There is no place in this scheme for the silver deposit used in screen-plate processes to block out light of unwanted colours.

Subtractive Transparency Processes.

Fischer and others, in Germany and elsewhere, proposed the manufacture of triple-layer films, each layer being made sensitive to one of the primary colours. Thus the top layer could be made sensitive only to blue and violet (the old " ordinary " type of emulsion), the middle layer sensitive to green, and the bottom layer sensitive to red. If all three emulsions were made so thin that their total thickness did not appreciably exceed that of a single-coated film, then such a triple film could be used in a camera to produce the necessary analysis of the coloured image into its three primary components. If now these three images were developed as negatives, turned into positives by the well-known reversal process, and the positive images in turn converted into the complementary colours, namely, yellow, magenta, and cyan, the coloured sandwich so produced should give a satisfactory reproduction of the colours of nature.

This will be understood if we consider a simple coloured pattern such as the Union Jack. If this is photographed on such a tri-pack film, the blue portion of the image will register on the top layer, the red on the bottom layer, and the white in all layers, for white light contains all three coloured components. If now this film is developed as a negative and reversed into a positive, then we shall have clear spaces in the top layer where the blue image appeared, clear spaces in the bottom layer where the red was registered, and clear spaces in all three layers where the white images appeared.

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Thus the finished film, when held up to the light, will be clear or white, throughout, in the position of the white crosses. There will also be a clear space in the cyan layer where the red image appeared, so that between our eye and the light we shall have yellow and magenta dye, the yellow absorbing the blue, and the magenta the green, allowing red light only to reach our eye. In the top layer there will be clear spaces where the blue image appeared, with magenta and cyan dye in the line of sight, absorbing the green and yellow respectively, permitting only blue to reach the eye. The same reasoning will indicate how all other colours in the spectrum are produced by this method.

In practice, while it is not difficult to produce an emulsion sensitive only to blue and violet, an emulsion sensitive only to green is most difficult to produce, although the normal orthochromatic emulsion, which is sensitive to blue and green, is available. If we introduce between the top two layers of the sensitive film, during manufacture, a yellow dye (which can be removed during processing), this will absorb any blue light going beyond the top layer, thus allowing only the green and red to reach the lower two. An orthochromatic emulsion can therefore be used in the second layer, and owing to the absorption by the yellow dye of the blue element, will record only the green, for this emulsion is not sensitive to red. It is quite practical to make a further emulsion sensitive to blue and red with a negligible green sensitivity, and this is therefore used for the bottom layer, recording only the red, as any blue is already absorbed.

The next big problem is the conversion of the reversed layers into the appropriate complementary dyes. Fischer proposed to do this by incorporating in each layer certain chemical substances which would react with a suitable developer to produce coloured dye-products in proportion to the silver being produced. Such chemicals to produce yellow, magenta, and cyan dyes were known and suggested in Agfacolor patents, but were not immediately applied commercially, for on the one hand there was great difficulty in preventing the dye-products wandering from one layer to another, and on the other hand there was a tendency for the sensitising of one layer to affect that next to it. For example, the bottom layer tended to react with the middle layer, producing a red sensitivity.

Kodachrome.—Mannes and Godowsky, working with the Eastman Kodak organisation, succeeded in overcoming certain practical obstacles in connection with these three-layer

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films, with the result that Kodachrome, first of all in 16 mm. cine size and later in 35 mm. still camera film, was placed on the market in 1936. In Kodachrome, the three beforementioned layers are used, with the yellow filter layer (which disappears during processing) between the top two layers. In the original Kodachrome process, after exposure in the camera, the three layers were developed as a negative and bleached in the usual way, and were then immersed in a dye-coupling developer which deposited cyan dye in direct proportion to the silver densities being developed. The top two layers were then bleached, re-developed in a dye-coupling developer to produce magenta in the top two layers in proportion to the silver images, after which the top layer only was bleached, and re-developed in a developer which deposited yellow dye in the correct proportion. At this stage we had the three colours accompanied by a developed silver image. This was dissolved away, leaving only the three dye images.

In practice this method was elaborate, requiring continuous machine processing, with carefully timed immersions in many baths. Later the process was considerably modified, the present method being to give the second exposure through the back of the film with red light, which affects only the red sensitive layer, which can then be dye-coupler developed to produce the necessary cyan image without affecting the other two layers, after which an exposure to blue light will affect the top layer, which in turn can then be colour-developed to produce the required yellow. Chemical fogging is used for the remaining middle layer, which is then treated in a magenta-forming dye coupling bath. This improved method considerably simplified processing and made practicable the handling of various sizes of sheet film as well as those of continuous lengths.

Agfacolor.—By 1937 the Agfa organisation had solved many of their initial problems, and placed on the market Agfacolor Neu, in which Fischer's original idea of incorporating colour formers in the respective layers had been made practical, means having been found to avoid wandering of the dyes. Such a structure made the processing of the film a much less complicated matter, for once the three layers had been developed as a negative, the film could be exposed to light, and immediately given a second development in a developer containing one of the reducing agents such as di-ethylparaphenylenediamine, which reacts with the colour formers to produce the three necessary dyes simultaneously, each in its

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own layer. After this it was only necessary to bleach the blackened silver associated with both the non-colour-coupled negative image and the colour-coupled positive image, when the plain fixing bath would dissolve away the bleached silver, leaving only the dye image.

These two films, one having the colour-couplers already in the emulsion, and needing only one colour-development, and the other having no couplers in the emulsion and so requiring the three layers to be developed separately, were the first reversal colour films to be commercially introduced, and though numerous other manufacturers have entered the field, all films still belong to one or other type.

At the time of writing, the remaining reversal colour films on the market are Adox, Anscochrome, Ektachrome, Ferraniacolor, Gevacolor, Ilfachrome, Kranzcolor, and Perutz Color. All, except Ilfachrome, have the colour-couplers in the emulsion and so, in principle at least, can be processed by the user or a trade house in an ordinary tank; the processing of Kodachrome and Ilfachrome is so complex that it has perforce to be left to the manufacturer or to a trade house with exceptional resources and special equipment.

The steps in processing a typical reversal colour film are as follows: first development, stop-bath, hardener, rinse, re-exposure, colour development, stop-bath, hardener, wash, bleach, wash, fix, wash and dry. As is evident, the series of operations is a good deal more complex than that involved in processing a monochrome negative film, but there is nothing difficult about it; exact adherence to the instructions for the particular film will ensure success, even at the first trial. First development, however, is very critical with some films, and precise temperature regulation—to within half a degree—is necessary at that stage. Excluding drying, the whole process takes about an hour and a quarter.

Exposure for Colour.

Those photographers who do not wish to master the details for processing their colour transparencies can nowadays confine their activities to the exposing of the material only, since processing services by the manufacturers and others are available. Such services have led to a very considerable increase in the use of colour films by amateur photographers, and the only difficulty which nowadays they must still contend with is the estimation of the correct exposure.

In monochrome photography there is a very wide range of

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exposures which can be given to any particular subject without impairing the quality of the result, and the more casual variety of "snapshot" photography owes much of its popularity to this latitude.

In colour photography, however, exposures must be judged very exactly indeed if a first-class result is to be obtained. It should also be borne in mind that, on the whole, colour films are decidedly slower than their monochrome counterparts. At the time of writing, speeds range from 10 A.S.A. (Kodachrome: Ilfachrome) to 160 A.S.A. (High Speed Ektachrome); most are about 50 A.S.A.

Although exposure guides in the form of tables are issued with each type of colour film, these will in general be found only of real value in straightforward subjects which can easily be classified. In those subjects which do not fall easily into the classifications listed a photo-electric exposure meter is invaluable as a guide to exposure, while the quality of the results obtained even from average subjects is higher when such a meter is used in preference to tables. Since, however, the efficiency of such items as camera shutters, meter sensitivity and lens transmission varies quite appreciably from instrument to instrument, the speed ratings for any particular brand of colour material given by its manufacturer, or by the maker of the meter, should be taken as a first approximation only. The photographer should therefore calibrate his own equipment by a series of trial exposures, based in the first instance on the given speed rating. The incident-light method of measurement has been found the most reliable for colour work.

Colour transparencies must be viewed by transmitted light, and viewing devices which enable this to be done without inconvenience are marketed in several forms for either daylight or artificial light viewing. The ideal way to view transparencies is, however, by projection in a darkened room. Care must be taken not to overheat the slide, as the dyes used may fade on prolonged exposure to heat or bright light. Occasionally the overall colour of a transparency can be improved by after-treatment, depending upon the particular process; alternatively, the film can be bound up in contact with a sheet of lightly-tinted Cellophane of colour complementary to the overall hue it is desired to subdue. Dufaycolor is best projected by means of a light corrected by a filter or otherwise so as to give an approximation to daylight colour temperature, but the subtractive processes are all made to give best results when projected by the aid of normal tungsten projection bulbs.

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Subtractive Prints from Transparencies.

The high degree of light absorption inherent in the additive processes makes it impracticable to print the three-colour réseau on a paper base and produce pictures in colour by reflection, but the subtractive processes, on the other hand, give images transparent enough to make this possible. At first thought it might seem simple to coat a paper base with the three layers described under the heading of subtractive transparency processes and to produce colour prints of good quality by projecting transparencies on to such a coating, and by reversal processing to obtain what is required. No printing paper for this purpose is available for amateur use, and though prints can be made from transparencies by some manufacturers and trade houses, it seems probable that they use an intermediate negative in colour film.

Gasparcolor. A very interesting subtractive print process, examples of which have been shown from time to time in the United States, but which so far has not been successfully commercialised, is known as Gasparcolor. This uses opaque white cellulose acetate as a base, on which the customary three emulsions are coated. In this case, however, the emulsions are not only sensitive to their respective colours, but have the complementary dyestuffs already incorporated in them. If the unexposed and unprocessed Gasparcolor sheet is brought into the light it appears black, owing to the superimposition of yellow, magenta, and cyan dyes in the three layers. White light falling on the surface of the Gasparcolor material has the blue component absorbed by the yellow dye, the green by the magenta, and the red by the cyan, so that none of the white light is reflected back to the eye. If an unexposed sheet of Gasparcolor has a normal colour transparency projected on to it, the emulsions will effect the necessary selection, and the processing, instead of adding colour, bleaches it out where required. Thus, blue light will affect the yellow dyed layer, and the processing will remove the yellow dye from this layer where the blue light has acted. If now the finished print is brought into white light, only the green and red components will be absorbed by the magenta and cyan layers, the blue light being reflected back to the eye from the white base. In the same way other colours are produced by selective absorption and bleaching out of the minus colours from the appropriate layers. Gasparcolor is much too slow to be used in a camera in the normal way,

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although prolonged exposures in a camera have produced very good results. Its field would appear to be, in the main, the production of colour prints by projection.

Direct Prints from Colour Negatives.

Kodacolor, the first negative-positive process, was introduced by the Eastman Kodak Co. in 1942 as a roll film which is processed by the makers to a colour negative, with light and shade reversed as in black and white negatives, and with the colours of nature reproduced as their complementaries. A girl's red lips, for example, appear bright green in the negative. From these complementary colour negatives the makers produce colour prints on paper, using special emulsions of the tri-pack type incorporating colour couplers in their respective layers.

In 1947 Kodak announced Ektacolor, a film very similar to the early Kodacolor in general type, but greatly improved by a system of automatic masking designed to correct for the deficiencies of the dyes used.

This automatic masking system is of considerable interest. The yellow dye, being near the ideal, does not need compensation. The function of the cyan dye is to absorb all red, but to transmit all green and blue. Unfortunately it absorbs an appreciable proportion of green light, as well as some blue. Accordingly a red-magenta mask, absorbing the same proportion of blue and green as the cyan dye, is added to this layer, and it has the characteristic that the mask-colour is discharged in proportion to the amount of cyan dye formed during development. Image formation in this layer thus leaves the transmission of blue and green unchanged, and affects only the transmission of red—which is exactly what is required. A similar yellow mask is used in the magenta layer to compensate for the unwanted absorption of blue by the magenta dye. As a result of these two masks, a finished Ektacolor negative appears strongly yellowish orange, but as the corresponding paper is balanced to allow for this, no heavy filtering is needed in printing.

In 1953 this integral masking was incorporated in Kodacolor, so that the two films are now virtually the same. Roll and 35 mm. films are called Kodacolor; sheet film bears the name Ektacolor.

The Ilfacolor negative film also includes an automatic mask, though in one emulsion layer only; the other negative

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films, which include Agfacolor, Ferraniacolor, Gevacolor, and Pakolor, do not use masks.

Negative colour films can quite successfully be used in either daylight or artificial light, for if the colour temperature of the light by which the exposure is made is not that for which the film is balanced, which naturally would introduce a colour bias, this bias can be eliminated by suitable choice of a correcting filter in exposing the print. Mixed lighting, however, must be avoided as carefully as when using reversal colour, for if artificial light and daylight appear in the same picture, either objects illuminated by the former will be too yellow, or those illuminated by the latter will be too blue.

The printing paper used for colour reproduction, like the film, is a tripack, and theoretically it should be possible for correct colour reproduction of all scenes taken in daylight to be obtained simply by printing or enlarging on the colour paper, provided that the colour temperature of the exposing light was standardized. Filters would then only by necessary when printing negatives taken by artificial light. In practice, such perfect balance of film, paper and exposing light is not attained, and filters are required for practically every subject if correct colour reproduction is to be obtained.

The three emulsion layers of the printing paper can be exposed either in succession or simultaneously. For the former technique three filters—red, green and blue—are needed, and the colour-balance depends on the relative proportion of the total exposure given through each. The advantages are that any enlarger can be used and only three filters are needed, but any kind of control by shading or the like is made very difficult. When the three emulsion layers are simultaneously exposed, a filter of the right depth and tint for the particular print being made has to be used; in practice this means that the operator must have a graded set of filters in each of the three colours, yellow, magenta and cyan. Each such filter has the effect of reducing the exposure given to one or other of the layers; if two are to be held back to increase exposure to the third, two filters are used together. Some special enlargers for colour work approach the problem rather differently; three quite deeply tinted filters are provided in a position where they can be inserted into part of the beam of light before it reaches the negative, and after passing partly through and partly past the filters the light is " scrambled " by being reflected and re-reflected in a mirror box or similar device, so that the light eventually reaching the negative is

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homogeneous. Depth of tint is controlled simply by the area of filter pushed into the beam of light.

Film and paper are processed by the same routine; colour development, followed by stop-bath, bleaching the developed silver, and finally fixing it out. With a wash between each stage and the next, processing takes nearly an hour to complete.

Colour Prints from Separation Negatives.

Earlier colour printing processes required three negatives of the subject, exposed either simultaneously or in rapid succession through the three primary colour filters. The resulting monochrome negatives, which are made on ordinary panchromatic plates, are then printed to give three monochrome positives, the image-colour in each case being complementary to that of the filter through which the corresponding negative was made. Thus the negative exposed through the blue filter is printed in yellow, that taken through the green filter in magenta, and that taken through the red filter is printed to give a cyan image. The three prints, when superposed in register, give the completed picture in full colour.

A carefully made print from separation negatives has excellently true colours, but there are evident difficulties. The need for perfect register implies a lens that gives images of precisely the same size through the different filters—which is not always achieved even by lenses that give perfectly acceptable results in making, say, a colour transparency on a tri-pack film. Plates are preferred to films for this work, because a glass plate cannot alter in dimensions during processing, which would lead to lack of registration in the final three-colour print. It will also be evident that at least two of the three coloured images must be transparent; if they were opaque a black, formed by a heavy density in all three images, would have the tint of the uppermost of the three superposed images.

The provision of transparent images in fact offers no great difficulty; it is the practical difficulty of obtaining a perfect set of colour-separation negatives that has always been one of the outstanding drawbacks to the use of such processes.

Successive Exposures. The simplest way is to use an ordinary camera and expose three plates in succession, each through its appropriate filter. This method demands that even under ideal lighting conditions the subject remains still for at least 20 seconds. Nevertheless, the majority of separation sets are made in this manner, which is, of course, the

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method used by the process engraver in preparing his screen negatives from flat copy colour originals.

Repeating Back on an Ordinary Camera. A repeating back is a dark-slide holding three panchromatic plates in front of each of which is a colour filter. The three exposures are made by moving the back over, by hand, between each exposure and the next, and the minimum time required for open-air work is approximately 7 seconds under midsummer conditions (Autotype Back). The back can also be arranged to bring each plate into position by gravity fall, being operated by an antinous release (Uvachrom Back). The total exposure in this case is less than with the hand-operated back, but not to an important extent.

Automatic Repeating Back (Vivex). In this instrument, the three plates, loaded side by side in one dark-slide, each behind its appropriate filter, are brought into the exposure position by clockwork mechanism. The controls are set to the desired exposure ratio and on pressure of the antinous release the three exposures follow each other in rapid succession, the overall exposure being of the order of 1½ to 2 seconds.

One-Exposure Cameras. In these, all three plates are exposed simultaneously, the light from the lens being divided up inside the camera by an arrangement of prisms or mirrors which divert appropriate fractions of the light on to the three plates. With such cameras, snapshots and flashlight instantaneous exposures are possible.

A properly made one-shot camera is an expensive instrument, and so far they have been of interest chiefly to professional photographers. The Bermpohl camera (Germany), Barker Devin (U.S.A.) and Vivex camera (England) are typical commercial models. All make use of mirror reflectors rather than prisms, the reflectors consisting either of very thin optically worked glass or pellicles in the form of collodion membranes. In order to ensure that each negative receives its appropriate fraction of the light entering the lens, the surface of the reflectors are partially metallised—usually with aluminium deposited from the vapour of the metal produced by cathode discharge in a high vacuum.

Separation Negatives. By whatever method the three exposures are made the object is to obtain three negatives of the subject whose contrast is identical. These negatives are usually identified by including in the subject as a reference chart a grey scale and patches of yellow, red and blue colour. The appearance of the patches on each negative enables the

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colour in which the negative is to be printed to be identified, while the grey scale provides a means of comparing the contrast in each negative. It is obvious that panchromatic negative material must be used, but all types are not equally suitable, and each manufacturer usually makes definite recommendations as to which of his products are suitable for the purpose. The filters required are listed as "tricolour filters."

Generally speaking, it will be found that even when the correct filter factors (*q.v.*) are used, the blue filter record will be of lower contrast than the other two for equal times of development, and it is necessary, therefore, to give extra development to the blue plate to bring the contrasts into line, as required.

Printing from Separation Negatives.

The Kodak Dye Transfer Process. The Kodak Dye Transfer process, is a development of earlier imbibition processes which, although frequently described in detail in works on colour photography, are no longer practised by serious workers. In its revised form (materials for which are issued by Kodak Ltd.) the separation negatives are enlarged on to a yellow-dyed silver bromide emulsion coated on a thin celluloid base. Exposures are made through this base, and the yellow dye confines light action to the regions in contact with the base. The exposed film is developed suitably and, without fixing, the developed image is then bleached.

After bleaching, the film is treated with warm water, whereupon all the gelatine except that in the immediate neighbourhood of the original silver image washes away, leaving a gelatine relief image on the surface of the celluloid. The three relief images are soaked in dye solutions obtained from Kodak Ltd., and then each in turn is briefly rinsed in very dilute acetic acid and squeegeed on to water-swollen gelatine coated paper.

The dyestuff transfers from the relief to the mordanted paper, where it is rendered insoluble, and the picture is complete when all three images have in turn been transferred into register on the support. The transfer takes several minutes to accomplish, and the sandwich is preferably placed in a copying press during the process.

Carbon and Carbro. These two processes offer the simplest means of making and superimposing the three coloured images, and Carbro in particular has been very widely used in the past. The procedure was exactly as described in the articles dealing

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with these processes, using special tricolour carbon tissues, developed on a temporary support and finally transferred, in register, to the final paper base. The necessary materials, however, are no longer made.

Chromatone. This process, which has not been revived since the Second World War, is typical of a large number which have been proposed wherein silver images of positive prints from the separation negatives are chemically toned to the appropriate colour before being assembled in register. Moreover, as with Dye Transfer, the success of Chromatone was due to the fact that the sponsors marketed suitable material for carrying out a process which, in its principles, has been known for many years. The nature of the Chromatone toning baths has not been published, but the materials, including the special collodion stripping paper on which the part images must be printed, were obtainable from the Defender Division of the Du Pont organisation of Rochester, New York.

Duxochrome. This German process was used both on the Continent and to some extent in the United States up to 1939, and has been revived in Germany since the war. As in the Eastman Dye Transfer process, exposure in Duxochrome printing is made from negatives through a transparent support on to a silver bromide emulsion. This emulsion, however, already contains in the form of water-insoluble pigments one of the three subtractive colours, and after development in a tanning developer the colour sheets are placed in warm water, when the untanned gelatine washes away, leaving a relief image. The three reliefs are then transferred to a single support as in the Carbro process.

Vivex. Before 1939 Vivex prints were offered, as a service to professional photographers, prints being made from their own separation negatives. The process used was Carbro, possibly modified a little, and worked in near-ideal conditions in a specially equipped factory near London.

Fuller details of all these processes will be found in *Colour Prints*, by Jack Coote (Focal Press).

Colour Screens. See FILTER; also SAFELIGHT.

Colour-Forming Developers. Developers so compounded that they dye the gelatine in proportion to the amount of silver image formed. Though the developing agent itself is usually colourless, the oxidation-product into which it is converted as a result of developing the image is either itself highly coloured or capable of combining with some auxiliary substance in the

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solution to form a dye. The second method is that generally used, as the same developing agent can be made to lead to a whole range of different colours according to the composition of the auxiliary substance chosen.

The silver image may be left, or may be dissolved away in Farmer's reducer or the like ; if this is done the final image consists entirely of the dye.

This method can be used for the production of monochrome prints or slides, but is more commonly applied to the making of the three separate coloured images used in subtractive colour work. See COLOUR DEVELOPING AGENTS; COLOUR PHOTOGRAPHY; and *Colour Cinematography* under CINEMATOGRAPHY; reference may also be made to *Making Colour Prints*, by Jack Coote.

Colour-Sensitive Emulsions. The early plates were almost completely insensitive to any but blue and violet light, and in consequence gave photographs in which coloured objects were quite wrongly reproduced. A yellow flower would be rendered practically black on the print, as would any object of a fairly pure red colour. Grass and leaves in a landscape were shown far too dark, and in portraiture the tiny bloodvessels under the skin, and any such minor blemishes as freckles, were grossly exaggerated, giving a most unflattering rendering of the sitter's skin texture. Blue objects, even if they appeared dark to the eye, were liable to print very light, as did the blue of the sky, which consequently merged with the clouds into a plain white area.

The sensitivity to various colours of a non-colour-sensitive emulsion is compared in Fig. 1 with that of the average human eye. The boundary between black and stippled portions shows the sensitivity of the eye to light of different wavelengths, while the boundary between white and stippled portions shows the sensitivity of the emulsion. For a strictly correct representation, in the photograph, of the visual brightness of colours, the two curves should be parallel throughout their length.

That non-colour-sensitive plates, used for everyday photography, do not give results so far from the truth as to be unrecognizable is due to the fact that natural colours are seldom, if ever, pure. Even a bright yellow or deep red object reflects *some* blue light, though it may be very little ; though such an object may be rendered far too dark, it is at least not shown as completely black.

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Colour-Sensitive Emulsions

The discovery that the addition of a dye to a photographic emulsion confers on it sensitivity to the portion of the spectrum absorbed by the dye was made in 1873 by Vogel, and by 1884 dry plates sensitised to green and named " orthochromatic " were commercially available. In these early plates, however, the green sensitivity was low compared with the sensitivity to blue, so that the latter still preponderated heavily, and there was no great advantage in using the new plates unless special means were used to check the effect of blue light. This was done by placing a deep yellow filter (see FILTER) over the lens and lengthening the exposure—often by as much as forty times. In this increased time the green light could have its due effect, and the blue light, greatly cut down by the filter,

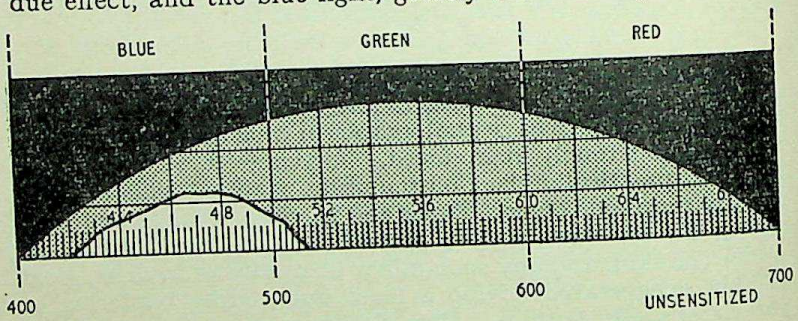

FIG. 1.

did not cause over-exposure. As the plates of that date were initially slow, exposures were thus made very long indeed, but satisfactory rendering of all colours up to green and yellow-green became possible.

In later years extensive research has produced sensitising dyes far more effective than the early ones in conferring sensitivity to green and yellow green, so that the sensitivity to these colours of a modern orthochromatic plate is hardly short of its sensitivity to blue. Fig. 2 shows a sensitivity curve typical of a roll film, or orthochromatic plate, of the nineteen-twenties, and comparison of this with Fig. 1 shows the very considerable improvement already brought about by that date by dyes sensitising as far as 5900 A.U. With such emulsions a yellow filter of quite moderate depth was sufficient to compensate for the remaining excess of sensitivity to blue, and the increase in exposure necessitated by the filter was only about five to eight times.

Still further improvement is shown in the curve of Fig. 3,

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typical of most of the current orthochromatic plates. Not only is the sensitivity to yellow-green increased, and that to blue decreased, but the dip in sensitivity at about 5200 A.U. shown in Fig. 2, and very much more marked in the earlier orthochromatic emulsions, has almost entirely disappeared. With these more highly orthochromatic emulsions a still paler

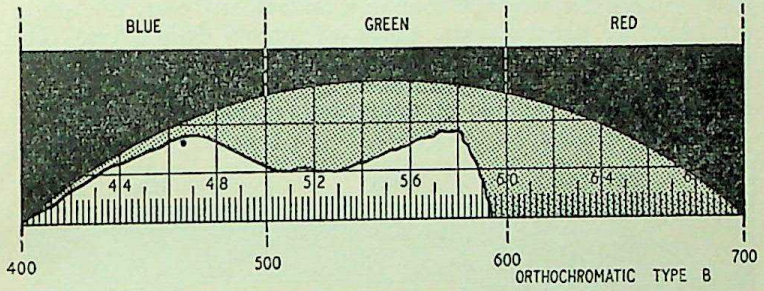

FIG. 2

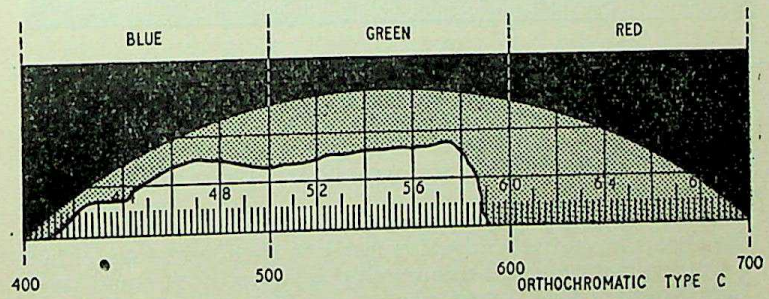

FIG. 3.

yellow filter, increasing exposure only some three or four times, is fully adequate to give pleasing colour-rendering of all colours but red and to retain clouds in landscapes.

As an orthochromatic emulsion is insensitive to red, it will reproduce as black any object of a pure red colour, but to set against this it can be handled and worked in a darkroom illuminated by a pure red light (see SAFELIGHT). Sensitivity to red, however, can quite readily be conferred by the use of suitable dyes, and a plate sensitised to red in addition to green

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and yellow-green is called *panchromatic*, being sensitive to all visible colours. Panchromatic plates were introduced last century, but their use was almost entirely restricted to special purposes—photographing spectra, paintings, furniture etc.—until about 1920, when their popularity began to grow rapidly. Panchromatic roll films were introduced before 1930, and by 1935 were widely used by amateurs of all grades of skill. As development is nowadays done in a tank in any case, the need for handling panchromatic material (unless desensitised) in complete darkness, or by an exceedingly dim green light, is no longer considered a disadvantage. Only panchromatic emulsions are now available in miniature (35 mm.) film, and in

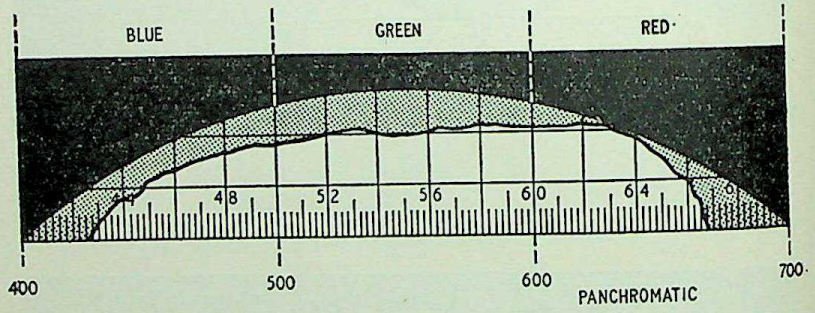

FIG. 4.

roll-film form the few orthochromatic emulsions still available are imported.

Owing to the preponderance of red and yellow in artificial light, panchromatic material is faster to such light than either orthochromatic or non-coloursensitive material of equal daylight speed. The fastest plates and films are therefore all panchromatic, though many slower panchromatic emulsions are also available.

Compared with orthochromatic material, a panchromatic film or plate has a less excessive sensitivity to blue. This implies that for equal colour-correction a less deeply-tinted yellow filter is required, and less increase of exposure is needed even with the same filter. These two factors together mean that in all work involving the use of filters a panchromatic film is in effect always considerably faster than an orthochromatic film of equal rated speed, and so requiring, without filter, the same exposure.

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It was at one time usual to make the fastest panchromatic emulsions disproportionately sensitive to red light, so enhancing their speed to artificial light. Portraits taken on them reproduced lips too light and blue eyes too dark. Recent advances in emulsion-making have made this device unnecessary, and the modern panchromatic emulsion, apart from the inevitable excess sensitivity to blue, has colour-sensitivity not greatly different from that of the eye. A typical curve is shown in Fig. 4.

See also FILTER, SAFELIGHT, and DESENSITISING.

Colour-Sensitometer. Abney's colour-sensitometer in its simplest form consisted of a series, or row, of coloured glasses, and a stepped sector-disc which rotated rapidly in front of these glasses ; so controlling the light that the visual luminosity of each coloured pane, considered as a window, was equal. Photographed on a truly orthochromatic plate all the windows would make equal impressions on the emulsion.

The modern method of estimating the colour-sensitivity of an emulsion is by means of a wedge spectrogram (*q.v.*). By the addition of suitable filters the curve shown may be shaped to almost any form, true orthochromatism being achieved when the spectrogram of emulsion and filter together take the form of the curve of visual luminosity. The adjustment of filter to emulsion may be made by calculation from a knowledge of the sensitivity curve of the emulsion and the transmission-curve of the filter, or by direct measurement of the combination.

Colour-Temperature. The composition of the light emitted by a glowing body (a lamp filament or a gas-mantle) depends on temperature, becoming more bluish and less yellowish as the temperature is raised. A lamp is said to give light of colour-temperature 3,000° A (see ABSOLUTE TEMPERATURE) if its light matches in composition that of a theoretically perfect radiator raised to that temperature. Light-sources giving line spectra, or a discontinuous spectrum, such as a neon sign or a household fluorescent lamp, cannot properly be said to have a colour-temperature, simply because the composition of the light they emit cannot be matched by that from a hot body.

Colour-films are balanced to give correct colour-rendering when used with light of one particular colour-temperature; for light of any other colour-temperature a correcting filter

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must be used. For example, Kodachrome Type A (for artificial light) is balanced for a 3,400° source, while daylight Kodachrome is balanced for 5,400° A.

See also MIRED.

The following table gives the colour-temperature of typical light-sources used in photography :—

Light Source	*Colour Temp.*	*Mired Value*
60-w household lamp	2800° K	357
100-w. household lamp	2860° K	350
200-w. household lamp	2900° K	344
500-w. projection lamp	3175° K	315
500-w. Studio lamp	3200° K	312
Colour-balanced photoflood	3200° K	312
Normal photoflood	3400° K	294
Speed Midget flashbulb	3300° K	303
Wire-filled flashbulb (clear)	3800° K	263
Foil-filled flashbulb (clear)	3800° K	263
Blue flashbulb	6000° K	167
Electronic flash	7000° K	143
Midday sunlight	5600° K	178
Midday sun plus blue sky up to	6500° K	154
Overcast sky up to	8000° K	125

See also LIGHT.

Colour-Temperature Meter. Meter for determining the colour-temperature of a light-source. The principle involved is the comparison of the brightnesses of the source as seen, by a photocell, through red and blue filters. The higher the blue content as compared with the red, the higher is the colour-temperature.

Colouring Photographs. Photographs may be coloured to approximate those of nature by various means. Water colours are most difficult to apply satisfactorily unless sprayed on with an air-brush, but with considerable practice and patience prints may be effectively tinted with water colours provided the surface is properly prepared for their reception. The gelatine of the print should first be hardened by the application of an alum bath or dilute formalin, well washed and dried. The surface should then be rubbed over with:—

Purified oxgall . . .	30 gr.	(4 gm.)
Pure methylated spirit . .	2 oz.	(125 c.c.)
Distilled water . . .	8 oz.	(500 c.c.)

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When the surface is dry the print is ready for the reception of the colours. A medium composed of a small quantity of the best gum arabic dissolved in water to which a few drops of glycerine have been added will be found better than plain water. Sable brushes should be used.

In most cases the oxgall treatment can be replaced by using water containing a wetting agent (*q.v.*) to dilute the tint. Very heavy colours (that is, very deep shades) need generally more gum in the medium to render them glossy on glossy surfaces; but such a medium is obtainable of most dealers supplying suitable colours. Certain colours may be blended or mixed with good effect, although it is generally better to apply one shade over another so that one colour will not destroy another.

Dyes and Stains are supplied by various photographic firms for colouring prints. They are very simple to apply with a brush to almost any surface. Full instructions for use are always given with these sets of colours. These stains or dyes, which are obtainable in liquid form, in powder (for dissolving in water) and in the form of leaves (such as the Kodak Velox colours) are specially useful for tinting lantern slides and transparencies; the beauty of the result depends entirely on the care and taste of the colourist.

Transparent oil colours, thinned with turpentine and megilp, can also be used very effectively for colouring prints. It is necessary that the gelatine surface should not be broken or cracked, or the oil will get through and stain the paper. The colours are best rubbed or smeared on with little wads of cotton-wool, and finer touches put in with leather or paper stumps.

Pastels can be used in a similar manner for tinting matt surface prints. The soft pastels can be applied either with stumps or wads of wool and subsequently fixed by steaming the print, or can be applied with the aid of a medium made by melting ½ oz. (10 gm.) of beeswax in a small jar standing in a saucepan of boiling water. Then add 12 grains (1 gm.) of potassium carbonate dissolved in 1 dram (5 c.c.) of water. Remove from the fire and add 1 oz. (40 c.c.) of turpentine. Stir and pour into wide-mouthed bottle to cool. Use the soft pastels and work up a little of the desired colour with some of the medium, so that it can be applied as a transparent tint with the stump. For further details, consult *Colouring, Tinting, and Toning Photographs*, by C. W. Walley.

See also FLEXICHROME.

Coma. Spherical aberration of non-axial rays. (See LENS.)

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Combination Printing. Term applied to the production of a print from two or more negatives—*e.g.*, a landscape from one, a figure from a second, and clouds from a third.

An outline of the method employed when printing by enlargement is given under ENLARGING (*q.v.*) ; the following notes refer chiefly to contact printing.

Printing in Clouds.

The clouds chosen must have been photographed under conditions of lighting similar to those by which the landscape was taken ; if clouds are lit from the left, and the landscape from the right, the falsity of the combined print will be self-evident.

First, the sky portion of the landscape negative, if it does not print white, must be rendered opaque by blocking out (*q.v.*). When the landscape has been sufficiently exposed, the negative is removed and replaced by the cloud negative, so that the required cloud-form comes over the blank sky. This is easy where a printing out paper, showing a visible image, is in use ; with gaslight or bromide paper pencil dots at the edge of the print must be used as a guide to the position of the skyline.

The necessary exposure for the cloud portion is now given, the landscape part of the print being shielded from further light. Where the skyline is level, or has a simple outline, a mask cut out of brown paper can be pinned on the outside of the frame to cover the landscape. The junction between sky and land will be unnoticeable provided that the light used for printing is sufficiently diffused to prevent the edge of the mask from casting a sharply-defined shadow.

When printing on a development paper of any type, the exposures required for the two negatives must be independently determined in advance by means of test-strips.

For a full treatment of the subject, refer to *Photographic Skies*, by David Charles.

Combining Lenses. See SUPPLEMENTARY LENS and LENS FORMULÆ.

Composite Portraiture. The late Sir Francis Galton, by throwing faint images of a succession of accurately-adjusted prints (or negatives) on the same part of an ordinary sensitised plate, obtained resultant images which give a pictorial average of all the constituents. Racial characteristics are brought out in a remarkable way in the composite photograph.

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Composition. A term denoting the grouping of the materials of a picture so as to form a pleasing and harmonious whole. (See PICTORIAL COMPOSITION.)

Concave, Concavo-Concave, Concavo-Convex Lens. See LENS.

Concentrated Acid. An acid in a form in which it is practically devoid of added water (conc. sulphuric or nitric acids), or in which the amount of added water is a minimum. Concentrated hydrochloric acid, which is a saturated solution of the gas HCl in water, is covered by the latter definition.

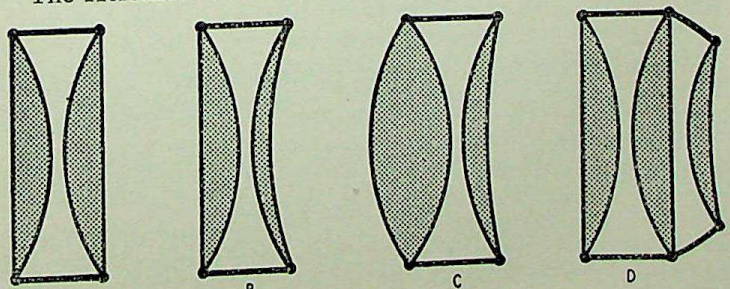
Concentrated Developer. For formulæ for concentrated developers, see paragraphs on Chlorquinol, Glycin, Metol-hydroquinone, and especially Paraminophenol, in article on DEVELOPMENT.

Concentrated Solution. Properly a solution in which the proportion of the dissolved substance is high. Sometimes rather misleadingly used when "saturated solution" (*q.v.*) is meant. (See SOLUTIONS AND SOLUBILITY.)

Condenser. A large lens, usually imperfectly corrected, used to collect or concentrate light upon a limited area. Photographically, the chief use of a condenser is in an enlarger or projector. (See ENLARGING for details of its use.)

A condenser may consist of a single thick lens, but danger from cracking as a result of heat from the illuminant makes it preferable, in most cases, to use two thinner lenses. The commonest form consists of two plano-convex lenses arranged as at A, which shows the type of condenser most often used in enlargers. For miniature enlargers, however, a single-lens condenser does not need to be so thick as to involve danger of cracking, and so is often preferred.

The Herschel condenser shown at C, in which the meniscus



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lens is placed next the light and the double convex lens next the negative or slide, is also sometimes encountered, particularly in projectors. The intermediate form B, using a meniscus next the light and a plano-convex lens next the slide, is occasionally used for projection with long-focus lenses.

The triple condenser D, consisting of a normal condenser as at A with the meniscus lens of a Herschel condenser added on the side next the lamp, is often met in small projectors, and has the advantage that it allows the lamp to be brought up closer to the condenser, so increasing the volume of light collected and giving a brighter image on the screen.

In an enlarger a diffused light-source is almost always used, so that the optical excellence of the condenser is of little importance. In projectors, however, it is essential that the image of the filament formed by the condenser should be as sharply defined as possible, and to minimise spherical aberration, which is the chief cause of an unsharp image, condensers with non-spherical surfaces are now widely used, especially in miniature projectors.

Condenser-lenses should always be mounted loosely enough in their cells to enable them to be turned round, or they may crack as a result of expansion when they are heated by the lamp. As an additional precaution, a heat filter (*q.v.*), should be used between lamp and condenser.

Conjugate Foci. Conjugate foci are corresponding pairs of distances from object to lens and from lens to image. Ability to work these out is useful in copying or in enlarging, since in both these cases the lens to image distance is considerably greater than the focal length.

If the object is n times as long as the image, or the image n times as long as the object, then the conjugate foci are:—

$$F_1 = (n + 1) f$$
$$F_2 = F_1/n$$

Where f is the focal length of the lens in use. The greater distance is on the side of image or object, whichever is the larger.

Example.—A 15 × 12 print is to be copied on a $3\frac{1}{2} \times 2\frac{1}{2}$ plate, using a lens of focal length $4\frac{1}{4}$ in. What will be the distance between (*a*) lens and print (*b*) lens and plate ?

If we make the image 3 in. long on the plate, the value of n will clearly be $15 \div 3 = 5$. One of the distances (F_1) will be $(n + 1) f = (5 + 1)\ 4\frac{1}{4} = 6 \times 4\frac{1}{4} = 25\frac{1}{2}$ in. The other, F_2,

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is $F_1/n = \frac{25\frac{1}{2}}{5} = 5\frac{1}{10}$ in. The latter is obviously the camera extension required, the former the distance from the object being copied to the lens.

The same calculation holds for the operation of enlarging 5 diameters, and the same results will be obtained. In this case the longer distance will be between lens and bromide paper. A table of conjugate foci will be found in the article on ENLARGING (*q.v.*).

Constant Density Ratios, Law of. This law, deduced by Hurter and Driffield in 1890 from their experimental results, states that the ratios of the densities of different parts of an exposed film or plate cannot be altered by varying the time of development. This amounts to saying that the relative densities of different parts of a negative, and hence the rendering of tones, is unalterably determined once the exposure is made, and that change in development-time can do no more than vary the overall contrast. (See SENSITOMETRY).

This law, however, does not apply where differently exposed parts of the negative receive different development, as when developing by a two-bath method.

Constants, Table of. See CALCULATIONS AND CONSTANTS.

Contact, Optical. Any two substances brought into close union one with the other, so as to absolutely join, and made to present but three instead of four surfaces, are said to be in optical contact. A familiar example is the common mirror, where the amalgam and glass are in optical contact.

Contact Paper. Under this name a variety of slow chloride paper—or a paper coated with a very slow gelatino-bromide emulsion, or a chloro-bromide emulsion (see CHLORO-BROMIDE and BROMIDE PAPERS; also EMULSION)—has achieved a very popular position among modern printing processes. Contact papers can be manipulated throughout in ordinary artificial light, without the necessity of a dark-room. Being slow, they are intended for contact printing only.

Practically every maker of bromide papers makes contact paper, which is supplied in cut sizes in packets. The packet of paper may be opened and the contents safely handled for the purpose of placing in the printing frame and developing in any room not too brightly lit with artificial light, provided that no direct light is allowed to fall on the paper.

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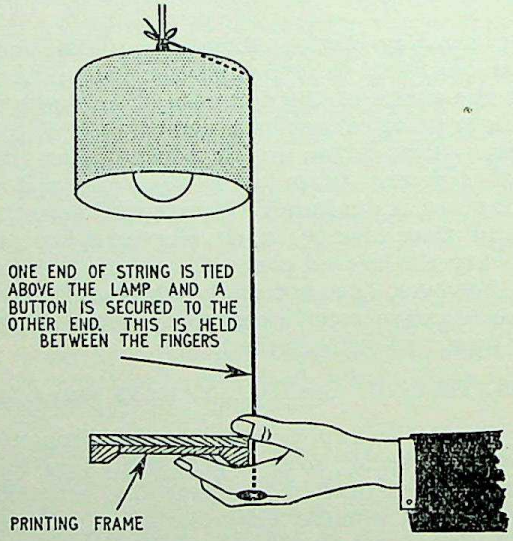
Exposure.

The paper is placed in contact with the negative in the printing frame, and the exposure is made while holding the printing frame at a distance of 6 to 12 in. from the light. Length of exposure varies with the density of the negative and the strength of the light.

As even a small error in the distance from the light at which the printing frame is held will make quite an appreciable



difference to the exposure required (see INVERSE SQUARES, LAW OF) the distance must be fixed in some way that will enable it to be repeated with accuracy. If printing is in progress in an ordinary living-room it is not always easy to arrange this; the sketch shows one simple method that has been found satisfactory in practice.

The best and most economical means of finding the correct exposure is to cut a sheet of paper into slips, and by placing a piece across a representative part of the negative and exposing it in steps, to make trial exposures. For a preliminary test, if the photographer has no idea of the exposure likely to be required, a " doubling-up " series of exposures should be given; 5, 10, 20 and 40 sec. at 12 inches from a 40-watt lamp may be tried. This slip should be developed for the full time, fixed and examined. If all steps are too dark, try the same exposures at

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three times the original distance from the light; if all are too pale, halve the distance and make a new strip giving double the exposures (10, 20, 40 and 80 sec.) Or replace the 40-watt lamp by one of 100 watts, and give the original exposures at 7 in. from it.

If one of the steps on the test-strip turns out to be of exactly the right depth, it is only necessary to give the corresponding exposure to a full sheet. If, however, one step is much too light and the next much too dark, as may happen with a very vigorous paper, a final test-strip using smaller exposure-steps may be needed to fix the exact exposure needed.

If the preliminary test-strip shows too much or too little contrast, a fresh test must be made with paper of softer or more vigorous character.

For prints after the first, a test-strip is hardly needed if the other negatives being printed are like the first in character. But in the end paper is saved if a test-strip is resorted to at once if there is any doubt either as to the exposure or the correct grade of paper.

When prints have to be done from various negatives an excellent plan is to classify them according to their density; then, by exposing the thinnest one first, and going progressively through them to the densest, the exposures can be very easily estimated.

If the negative to be printed from is denser on one side than on the other, the dense side should be brought more directly opposite the light, or the frame may be placed at an angle to it. Further exposure may be given to dense patches by waving a pocket torch, or even a lighted match, close to these particular parts of the negative either before or after the usual exposure.

Other Light-Sources. Contact paper may be printed by any fairly powerful artificial light, or by the light from burning magnesium ribbon. The *Ilford Manual* gives the following relative exposures for different light-sources :—

40-watt gasfilled bulb . .	5 sec. at 12 in.
Incandescent gas . . .	5 sec. at 12 in.
Paraffin lamp (Duplex burner) .	30 sec. at 6 in.
High Pressure Spirit Lamp .	12 sec. at 18 in.
Magnesium ribbon . . .	1½ in. at 30 in.

Speed of Paper. Contact papers of different makes may have very different speeds, and the more contrasty papers are

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in most cases slower than the softer papers of the same make. The speed of any one paper is not necessarily the same from batch to batch, and both speed and contrast may change as the paper ages in storage. But contact papers as a whole have about one-hundredth of the speed of bromide paper.

Development.

Development of contact papers is rapid, being complete in about 45 to 60 sec. at 65° F. with most brands. The makers instructions should be consulted on this point. The developer prescribed by the makers should in every case be used, as some contact papers are very sensitive to even slight variations in the composition or strength of the developer. This is particularly the case with the more vigorous grades.

The following developer is typical, and may be used with success with many, but not all, of the papers on the market.

Metol	15 gr.	(1·75 gm.)
Sodium sulphite (cryst) . .	440 gr.	(50 gm.)
Hydroquinone . . .	60 gr.	(7 gm.)
Sodium carbonate (cryst) .	660 gr.	(75 gm.)
Potassium bromide (10 per cent. solution) . . .	40 min.	(4·5 c.c.)
Water to	20 oz.	(1000 c.c.)

This developer keeps for long periods in a well-corked bottle, and is used undiluted.

The amount of bromide determines the colour of the finished print. Too much produces greenish prints, and insufficient gives a blue-black with a tendency to fogged whites. If blue-black tones are required, the potassium bromide solution of the formula may be replaced by an equal volume of a 2 per cent. solution of 6–nitrobenziminazol. The proprietary " developer improvers " act in a very similar way. The addition of 8 to 16 parts of a ½ per cent. solution of potassium thiocyanate to each thousand parts of developer has also been recommended.

The amount of sulphite should in no case exceed that given in the maker's formula for the paper in use, as excess of this constituent tends to cause a yellow stain similar in its nature to dichroic fog.

The exposed paper should be placed face upwards in a clean developing dish and the developer flowed over it with a sweeping motion. The image should flash up very rapidly,

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and development should be complete in 45 to 60 sec., with normal exposure and at normal temperature. A careful watch should be kept for bubbles adhering to the print; these should be broken with the tip of the finger. If development is not completed within 60 sec., unless the developer is exceedingly cold, or diluted, or additional bromide has been used, it may be taken for granted that the exposure has been insufficient. Nothing is gained by trying to force development. It merely conduces to fog through prolonged exposure to the light, or to yellowness from the developer.

The same developer may be used for several prints in succession, so long as it remains free from discoloration. It should be returned to a measure after the development of each print, ready to flow over the next one. When a number of prints are being done, a little fresh developer should be added from time to time to keep up its bulk and energy.

As soon as full detail is out in the print it should be rinsed for a second or two in clean water, and transferred at once to a stop-bath or an acid fixing bath. (See ACID FIXING BATH; also FIXING.)

The fixing solution should, if possible, not be handled until all the developing is done, as even the minutest trace of hypo in the developer, or contact with hypo at any stage previous to fixing, will cause stains in the prints. Stains may also occur if the prints are allowed to rise above the surface of the hypo, or subsequent washing water. (See STAINS.)

Stains can also be caused by allowing the prints to lie one over the other, particularly when not thoroughly freed from all traces of developer. If the acid in the fixing bath is not exhausted, and if the prints are thoroughly but *quickly* rinsed prior to immersion in it, and then kept well under the surface of the fixing bath and constantly on the move, there is very little chance of brown or yellow stains.

Other causes of yellowness or brown stains are :—Too weak or exhausted developer, under-exposure and forced development, or allowing the air to get at print while wet with developer.

Warm Tones by Development.

With some makes of contact paper warm tones can be obtained by increasing the exposure and diluting and possibly also restraining the developer. The procedure is much like that used with chlorobromide papers (*q.v.*).

The metol-hydroquinone developer given before, used in conjunction with ammonium carbonate, will produce colours

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ranging from sepia to red chalk, according to the exposure and dilution with water.

Cool to warm sepias.—Exposure : 5 to 6 times black.

Metol-hydroquinone developer (as for black)	1 oz.	(32 c.c.)
Ammonium carbonate solution (see below)	50 to 60 min.	(4 c.c.)
Water to make	6 oz.	(200 c.c.)

Warm brown to red.—Exposure : 6 to 8 times black.

Developer	1 oz.	(32 c.c.)
Ammonium carbonate solution	¼ oz.	(8 c.c.)
Water to make	8 oz.	(250 c.c.)

Red chalk.—Exposure : 8 to 10 times black.

Developer	1 oz.	(20 c.c.)
Ammonium carbonate solution	½ oz.	(10 c.c.)
Water to make	20 oz.	(400 c.c.)

Red development may take five minutes or more.

Ammonium Carbonate Solution.

Ammonium bromide	1 oz.	(50 gm.)
Ammonium carbonate	1 oz.	(50 gm.)
Water to make	1 pint	(1000 c.c.)

The ammonium carbonate must be of good quality and in clear lumps, not white powder. It spoils if left exposed to the air. (See AMMONIUM CARBONATE.)

The following hydroquinone developer, simply diluted with water, is also stated to give a surprising range of colours on some brands of contact paper. The table shows the relative increase of exposure and dilution necessary.

The developer is :—

Water	20 oz.	(1,000 c.c.)
Sodium sulphite (anhydr.)	550 gr.	(62·5 gm.)
Hydroquinone	140 gr.	(16 gm.)
Potassium bromide	90 gr.	(10 gm.)
Sodium carbonate (anhydr.)	890 gr.	(100 gm.)

Dissolve in order given.

Tone of the dry print.	Exposure.	One part developer to be diluted with:
Blue-black	Normal	Undiluted
Green-black	Normal	5 parts water
Olive-green	Twice Normal	5 parts water

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Tone of the dry print.	Exposure.	One part developer to be diluted with:
Sepia	Three times normal	10 parts water
Brown	Four times normal	10 parts water
Red-brown	Six times normal	20 parts water
Yellow-brown	Eight times normal	20 parts water
Blood-red	Nine times normal	30 parts water
Red-orange	Ten times normal	30 parts water
Yellow	Twenty times normal	40 parts water

Contact prints, after development and fixing, are washed and dried in the same manner as bromide prints. They can then be toned in any of the toning baths recommended for bromides (see TONING) and, in fact, can be treated in exactly the same manner for all after-processes.

For Contact Lantern Plates, see LANTERN SLIDES.

Contact Printing. Printing processes in which the sensitive paper, such as P.O.P., bromide or slow contact paper, is exposed in contact with the negative in a printing frame—not by the image being projected on to its surface, as in enlarging.

Contrast. In general, the degree of differentiation between different tones. A negative is said to have high contrast if tones but slightly different in the original subject show marked differences in the negative. Used in this sense, the term really refers to the gamma to which the negative has been developed (see SENSITOMETRY).

If the overall range of densities in a negative or print is high, it may again be said to be of high contrast, even though the contrast may be due entirely to the subject and may not have been accentuated in the photographic process. From the point of view of the final result, contrast is most important in its latter sense, which is in consequence the sense in which it is most used by practical photographers.

The contrast of a negative may be expressed numerically by the ratio of the opacities of the lightest and densest deposits which are required to print. In an average negative the shadows may pass perhaps twenty times as much light as the highlights; clearly the figure 20 adequately expresses the contrast of that negative. In place of the ratio of the opacities, the difference between the extreme densities is often used. As density is expressed in logarithmic units, this simply means that in the case just mentioned the contrast would be quoted as 1·3, this being the logarithm of 20.

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In practice the contrast of the negative is controlled by development; though it can also be controlled to some extent by exposure, this inevitably leads to falsification of tone-values. Intensification and reduction (*q.v.*) offer means of altering the contrast of a finished negative, but these processes lost much of their one-time importance when paper in various grades of contrast (see CONTRAST GRADES), became universally available.

Contrast Filter. Colour filter chosen to give a sharp contrast between objects of two different colours, irrespective of the theoretical correctness or otherwise of the rendering. In photographing, for example, red flowers against green leaves, it might so happen that the depth of tint was the same for both, so that if correctly rendered into monochrome the two would be barely distinguishable. Through a red filter the flowers, and through a green one the leaves, would come out much the lighter of the two. (See FILTER; also *Copying Coloured Objects* under COPYING. See also *Multigrade*, under BROMIDE PAPER.)

Contrast Grades. Practically all development papers (contact, bromide, or chlorobromide) are obtainable in different grades characterised by names such as "vigorous," "normal," "soft," and the like. Often as many as six grades are offered. A series of prints, each on a different grade of paper, would show increasingly contrasty results as the paper used was changed from "soft" towards "vigorous." A negative of any degree of contrast, so long as it is not unreasonably high or low, will give a print of correct contrast if the grade of paper is suitably chosen.

The wide range of grades available in modern papers is illustrated by the following approximate figures, which refer to the five different grades in which one maker offers bromide paper. The contrast-range of each paper is here expressed as the ratio between an exposure long enough to give a grey so dark it can barely be distinguished from full black, and that required to give the lightest tint that can be distinguished from white.

Grade A (softest)	1 : 28
Grade B	1 : 14
Grade C	1 : 9
Grade D	1 : 5½
Grade E (hardest)	1 : 4

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In such a series, grades B and C, or even C and D, would probably be those most used by the miniature worker, who habitually makes soft negatives as a result of the need to avoid grain, while the large-camera user would in most cases use grades A and B.

Silver printing-out papers have a range of about 1 : 60, carbon paper a range of about 1 : 80, while for the platinum process (and presumably other processes based on the sensitising properties of iron salts) a very contrasty negative of range about 1 : 100 is required.

(See also PAPERS, PHOTOGRAPHIC, TESTING OF)

Contrast Range of Subjects. See LUMINOSITY.

Control Processes. Term sometimes used to designate those processes—bromoil, gum-bichromate and a few others—that allow the photographer considerable manual control over the photographic image.

Convertible Lens. A lens the single components of which are capable of being used alone as long-focus lenses having a narrower angle of view than the complete lens used as a whole.

Copper Sulphate (Fr., *Sulfate de cuivre*, or *Vitriol bleu*; Ital., *Sulfato di rame*; Ger., *Kupfersulfat*, or *Kupfervitriol*) $CuSO_4$, $5H_2O = 249{\cdot}7$. Synonyms: Cupric Sulphate, Blue Copperas, Blue Vitriol. It occurs in beautiful blue crystals, some of very large size. Copper sulphate is used in the copper toning bath and in the preparation of bleachers for intensification, toning, and the bromoil process. Solubility: 100 parts of water at 59° F. dissolve 29·7 parts of the crystals.

Copper Toning. See TONING.

Copying. Term applied to the duplication, by photographic means, of any photograph, sketch, painting, or drawing. The original is photographed by means of the camera in the ordinary way, using if necessary a plate or film of special type and prints are made by contact or enlargement from the resulting negative. Though a plate camera is almost universally used, methods and materials depend to some extent on the nature of the original; the subject is therefore divided into sections.

Black and White Copying.

In copying a line drawing or engraving, for which blank white and solid black are the only two tones required, a

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" process " or similarly-named plate is required, in conjunction, in most cases, with a heavily restrained developer, usually hydroquinone-caustic. Since, to fill the plate, the object must be near, a camera with long extension must be used; alternatively, a supplementary lens (*q.v.*) can be used for focusing. Should the paper show grain the subject must be so lighted that it is invisible, which can usually be done by using a full frontal lighting, or by even all-round illumination such as can be had out-of-doors. A simple box reflector, on the lines of that shown in Fig. 1, is a great convenience for artificial

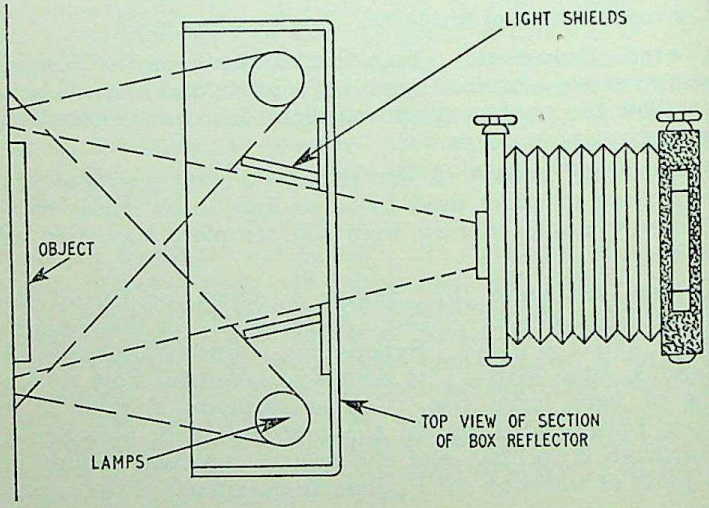

FIG. 1.

light work, as it avoids all danger of direct light reaching the lens.

Often some support is needed to keep the page of a book or a print flat; this support may be a piece of wood to which the original is pinned, or, if pins are inadmissible, to which it may be held by rubber bands. Alternatively, it may be copied through a sheet of good quality glass against which its face is pressed.

For fairly close-up copying, allowance must be made in exposure for the extra extension of the camera (see EXPOSURE). A small stop is commonly used to ensure sharp definition.

For development a heavily-restrained developer is generally

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preferred (see *Hydroquinone*, in article DEVELOPMENT). The main point is to retain clear glass in the lines representing the blacks of the original, while at the same time developing the dark part representing the paper to the highest possible density. Correct exposure is required to combine these two, though much can be done after development by " cutting " or reducing the plate in strong Farmer's reducer (see REDUCTION) to clear the lines, and then intensifying by one of the more drastic methods (see INTENSIFICATION.)

From the practical point of view, procedure is best determined by choosing a plate or film recommended by its maker for line copying, and following the instructions he provides as to exposure and development.

Copying Photographs.

The procedure is much the same as in line copying, except that a plate of less tendency to contrast is used in conjunction with a normal developer. A slow plate, preferably non-panchromatic so that it can be developed by inspection, is most suitable. Development should be so controlled as to give a negative comparable in appearance with that which might have been expected if the exposure had been made on the original subject instead of on a photograph of it.

Faded Photographs. First clean the print by rubbing it gently but firmly with a tuft of dry cotton-wool to remove the surface dirt that it is sure to have collected. Lighting should be as for line copying ; in addition to any grain the paper may have, the surface is likely to be covered with minute cracks which must not be allowed to show. Focusing can be made easier by pinning a strip of printed matter across the face of the photograph being copied, but do not forget to remove it before exposing.

Faded prints fall roughly into two categories. Those in which the image itself has partly faded away, leaving usually a pale yellow coloration to replace the original black, brown, or purple image, are best photographed either through a deep blue filter, or more simply, on a non-colour-sensitive plate which will respond to practically nothing but blue light. In this way the yellowed image photographs at nearly its original strength. If, however, the image is more or less intact, but the paper support has yellowed, a slow orthochromatic or panchromatic plate should be used in conjunction with a deep

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yellow, or even orange, filter. The yellowed whites will then photograph as white.

Copying Coloured Objects.

For all work of this type slow panchromatic plates are desirable, for by suitable choice of filter they can be made to give almost any result, true or false, that may be required. If the colours are to be rendered with the same relative luminosity that they present to the eye, the filter made for "full correction" with the particular plates used should be chosen. But it may happen that in the original a green and a red of equal visual luminosity come together; although completely distinct to the eye, they will merge into one another if correctly represented in monochrome. By the use of a filter either redder or greener than that recommended for "full correction," either the red or the green, as desired, may be made to photograph as the lighter of the two. Enormous help in choosing a filter for such difficult work as this may be had from a viewing filter (*q.v.*) which shows the subject more or less completely in monochrome as it will appear, with any chosen filter, in the finished print.

For all coloured objects, and for oil-paintings in particular, the best light is daylight. In copying oil-paintings the question of lighting is particularly important, as a side-light will show up the brush-marks very clearly. While for technical reasons an artist may desire to see the brush-marks, for ordinary purposes a reproduction from which they have been as far as possible eliminated will always be preferred.

General Notes.

If distortion is to be avoided, plate and original must be strictly parallel. Where the original is rectangular and has well-marked edges, parallelism is ensured when all four edges of the image are parallel to the edge of the plate. If the edges are not available as a guide—as, for example, if part only of the original is to be included—parallelism must be checked by measurement. With the image centred on the focusing screen, the centres of all four sides of the camera-back should be equidistant from corresponding points on the original. A piece of ordinary string may be used for measurement. If much copying is to be done, a copying-bench, consisting of an easel for originals mounted on a bed along which slides a carrier for the camera, will save an enormous amount of time

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in setting-up. A simple arrangement of this kind, with ruled lines as a guide to parallelism, is shown in Fig. 2.

A tripod is the worst possible support for the camera, as every movement to or from the original makes relevelling necessary, and in doing this the distance is upset again. A

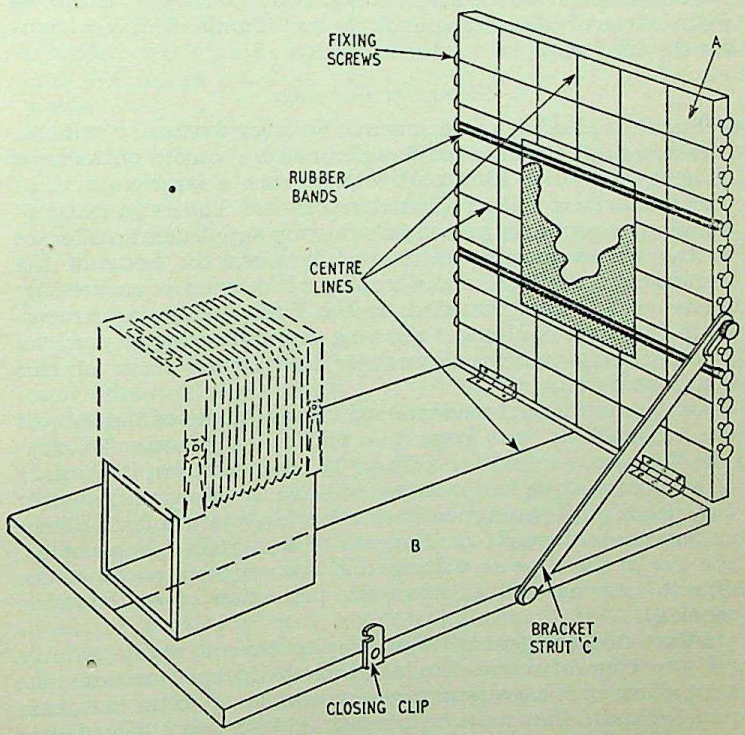

FIG. 2.

studio-stand, or a tripod stood on a board so that it can be moved about bodily, is very much easier to handle.

The baseboard and upright of a vertical enlarger form an ideal copying-stand if the camera can be attached to the sliding arm in place of the projector-head of the enlarger. Alternatively, the enlarger itself may be used (in the dark room only) as a copying camera, the plate being put in the negative-carrier and the original pinned to the easel. The

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original is framed in the rectangle of light projected when the negative-carrier is empty ; a negative is then inserted and the image is focused on a piece of white paper laid across the original. Check again for framing (focusing will have altered the size of the frame), switch off enlarger light, put a plate in the negative-carrier, swathe the slot in which the carrier moves with velvet or other opaque cloth, and illuminate the original for the time required for the exposure.

Microfilm Copying.

For the recording of documents, whether written or printed, it is now quite usual to employ a miniature camera of the type using 35-mm. cine film, particularly when a large number of documents have to be copied at one time. The extra range of focusing required is provided either by supplementary lenses or by extension tubes interposed between the body of the camera and the lens, and accuracy of focusing is ensured by reference to tables provided by the maker of the apparatus. More elaborate equipment allowing visual focusing on a screen is often preferred by those who have much work of this character to do.

On 35-mm. film three standard arrangements of the subject are recognised ; one page to each 24 × 36-mm. (" Leica-size ") frame, one page to a frame 18 × 24 mm. (or, in the case of a book, a complete opening on a 24 × 36-mm. frame), or two pages (an opening) to each 18 × 24-mm. frame. Choice among these depends on the size of the pages being copied, the size of the type or writing, and the resolving power of the film in use, as well as upon the perfection of reproduction required.

Films sold for general photography are not really suitable for any type of micro-copying, though if exposures must be kept short, or if no alternative is available, an extra fine grain panchromatic film may be pressed into service. The degree of reduction, however, must be kept moderate, as the resolving power of such films is not high.

Where colour-rendering is unimportant and economy must be studied, positive film, as sold for making positive copies (for projection) from professional cine-negatives, makes a very satisfactory material. In copying printed matter, the degree of reduction should be such that, on the negative, there are not more than 90 lines of type per inch. At this reduction, a complete opening (two pages) of this book would measure 15·5 × 19·4 mm. and could comfortably be accommodated on an

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18 × 24-mm. frame. A smaller ratio of reduction will give more satisfactory results.

For the finest resolution, and for all coloured objects, one of the slow panchromatic films specially designed for the work should be used (*e.g.*, Ilford Micro-Neg ; Kodak Microfile). With this type of film printed matter may be reproduced at up to about 180 lines of type per inch, and at this reduction four complete openings (8 pages) of this book could be included on a cine-size frame (18 × 24 mm.), or 16 pages on a Leica-size frame.

It will be observed that in copying any but large pages, the maximum degree of reduction cannot even be approached unless a number of pages can be spread out so as to be included on one negative. For copying small books, therefore, 16-mm. film (frame size 7·5 × 10·5 mm.) is often used professionally. An amateur cine camera, if capable of exposing frame by frame, may also be used. Each frame would just barely take a complete opening of this book, or would yield a very perfect negative of a single page.

It is often stated that miniature camera lenses give their best definition at about *f*/6·3, and that, as no depth of focus is required when copying, they should not be stopped down to smaller apertures. This argument is fallacious ; best definition may be given at *f*/6·3 *in the centre of the field*, but further stopping down almost always improves marginal definition. It is usually found best to stop down to *f*/11 or *f*/16, but experiment with the particular lens to be used must settle the best stop in any individual case.

Exposure in document copying should be such that the lines are practically clear, and development should not be too prolonged, or definition will suffer. A correctly-developed negative will not give a print in full black and white on any but a decidedly contrasty paper. Any attempt to imitate the traditional large-camera negative, with clear lines and completely opaque " whites," will lead to very noticeable loss of sharpness. The developer, and the development time, should be as recommended by the maker of the film in use. Fine-grain developers are generally not needed, owing to the very fine grain of the film itself, but they may be helpful occasionally when the degree of reduction is extreme.

Prints are not usually made from microfilm negatives ; instead the negatives themselves—or sometimes contact positives on 35-mm. film—are read in a special magnifying viewer.

For large-scale commercial work special equipment and

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cameras such as the Recordak (Kodak Ltd.), have been introduced, and save much time where a large number of pages have to be copied. See also AIRGRAPH. For further details, see *Document Photography*, by H. W. Greenwood (Focal Press.)

Exposures in Copying.

As already indicated, exposures in copying, especially in line work, are much more critical than in ordinary general photography, owing to the much higher gamma (contrast) to which development is carried. Work should therefore be done by artificial light, which is much more constant than daylight, and wherever possible a trial exposure should be made. The following tables, adapted from *The Ilford Manual of Photography*, give a very close estimate of the exposure likely to be needed in any given case.

TABLE I.—EMULSION SPEEDS

A.S.A. Speed	*Factor*
25	0
12	3
6	6
3	9
1½	12

TABLE II.—DISTANCE OF LAMPS FROM COPY

Distance	*Factor*
1 ft.	0
2 ft.	3
3 ft.	5
4 ft.	6

It is assumed that the lamps are in efficient reflectors.

TABLE III.—WATTAGE OF LAMPS

Watts	*Factor*
4000	0
2000	3
1000	6
500	9
250	12
125	15
60	18
30	21

One No. 1 photoflood is equivalent to an 800-watt lamp (Factor 7). Factor for two photofloods, 4.

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TABLE IV.—LENS APERTURE

Stop	*Factor*
f/5·6	0
f/8	3
f/11	6
f/16	9
f/22	12
f/32	15

TABLE V.—SCALE OF REPRODUCTION

Reduction	*Factor*
To $\frac{1}{4}$ or less	0
To $\frac{1}{2}$	3
Full size	6

TABLE VI.—TYPE OF SUBJECT

Subject	*Factor*
Black line drawings on white paper: printed matter	0
Matt or semi-matt prints; pencil or ink sketches	6
Contrasty glossy bromide prints; black photogravure prints	9

TABLE VII.—EXPOSURES

Total of Factors	*Exposure*
21	$\frac{1}{16}$ sec.
24	$\frac{1}{8}$ sec.
27	$\frac{1}{4}$ sec.
30	$\frac{1}{2}$ sec.
33	1 sec.
36	2 sec.
39	4 sec.
42	8 sec.
45	16 sec.
48	32 sec.
51	64 sec.

To determine the exposure, pick out from each of Tables I to VI inclusive the factor corresponding to the conditions of work, add them together, and find from Table VII the exposure corresponding to the total of the six factors.

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Copyright. Under the Copyright Act, the copyright in a photograph belongs to the person on whose initiative the photograph was taken. Normally this means the photographer himself, but a professional portrait photographer taking a portrait on the request of a sitter, and in expectation of payment, is considered to be acting as the employé of the sitter, to whom the copyright consequently belongs. By long trade custom, however, the negative itself is the property of the photographer, though he may only use it as the customer may direct.

If, however, a photographer, professional or amateur, takes a portrait on his own initiative, with no expectation that the sitter will pay him for it, then both copyright and negative belong to him, and he may do as he likes with both, provided that it is not to the disadvantage of the sitter.

Similar considerations apply to the press photographer; copyright in photographs taken in the course of his employment belongs to his employer.

It is important to note that copyright is in the photograph, not in the subject. It is infringement of copyright to copy someone else's photograph, but perfectly legal to make, on the original subject, an exposure from the same viewpoint, even if this produces a photograph virtually indistinguishable from an already copyright print.

No formalities have to be complied with to secure copyright; it exists automatically in every photograph, and lasts for fifty years from first publication of the picture. The author of a photograph may assign the copyright to another person, but such assignment must be in writing. The copyright then remains the property of the new owner until twenty-five years after the death of the author; it then reverts to the author's legal personal representatives.

Infringement of copyright consists in producing or reproducing a work, or any part of it, in any form. It is equally infringement to sell, hire, or exhibit infringing copies by way of trade or so as to prejudice the owner of the copyright; or import them for sale or hire.

An infringer is exempted from liability to pay damages, etc., if, in defending any action, he proves that he was not aware that there was copyright in the infringed work and had no reasonable ground for suspecting the fact.

Photographers can obtain civil remedies (damages, injunctions, etc.) for infringement of copyright; or, where

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infringement is shown to have been done knowingly, summary remedies (fines and imprisonment) against the infringer.

Infringing copies may be prevented from importation into the United Kingdom by notice to the Customs Commissioners.

Copyright photographs made before July 1st, 1912, obtain copyright as defined by the 1911 Act. Its term is that (fifty years) provided by the 1911 Act, reckoning from the date of first production.

Under " Photographs " are included photo-lithographs and all prints made by any process analogous to photography.

International Copyright. Copyright is granted in practically all civilised countries, with the exception of Holland, which at the present time has no copyright laws. Certain countries of the world have formed themselves into an International Copyright Union, so that the creation of copyright in one of these countries automatically gives copyright protection in all the other countries of the Union, according to the copyright law of each particular country and not necessarily that of Great Britain. The countries forming the Union agreed to this at a convention at Berlin in 1908. The following are the countries in which international copyright obtains :—Great Britain, France, Germany, Belgium, Italy, Denmark, Spain, Sweden, Switzerland, Norway, Portugal, Japan, Luxembourg, Hayti, Liberia, Monaco, and Tunis. Notable absentees from the International Copyright Union are the U.S.A. and the U.S.S.R. but it is quite possible for non-American owners of copyright to obtain protection in the U.S.A. by separate registration, and the same applies to a certain extent to other countries not in the Union.

The full text of the Berlin Convention in French and English, relating to international copyright law can be obtained from Messrs. Wyman & Sons, Ltd., 8 Great New St., London, E.C.4.

Corks. Corks are of considerable importance to photographers, as upon them frequently depends the keeping qualities and stability of chemicals in everyday use. Perfectly sound corks should always be used for bottles containing liquids or any chemical liable to deterioration by exposure to air. Rubber bungs are preferable for any strongly alkaline solution (including sodium sulphide) and for bottles containing mixed developers.

An ordinary cork, though watertight, is not always airtight, but it can be made airtight by soaking it in melted paraffin wax. The wax should be hot, and the cork pushed below the

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surface with a piece of wood. The heat drives some of the air out of the cork, so that when it cools some wax is sucked into the pores. Ordinary candle-ends melted in a jam-pot will serve.

Many chemicals for photographers are supplied in bottles with thin flat-topped corks cut on a level with the bottle-neck top, so that there is nothing to get hold of. The usual procedure is to dig the cork out with the point of a pair of scissors. This usually damages and not seldom spoils the cork. If one exercises a little patience, the cork can be removed without harming it, by inserting the point of a broad knife-blade between the cork and neck and raising the cork a trifle, then, shifting the point, repeating, and so on, working round the cork. If this fails, then use a fine bradawl pushed into the cork from the top edge towards the opposite lower edge, but do *not* let the tool go right through the cork.

Having got such a flat thin cork out, then insert one or two layers of waxed tissue paper between the cork and bottle before inserting, and leave a fringe (about an inch wide) of paper all round. This will form a kind of handle, and enable the cork to be removed with ease at any future time. If the cork is large, a couple of lengths of thin but strong cord can be tied round the cork, forming a loop to pull it out with.

Cosine Law. The illumination of a plate or film is brightest on the axis of the lens and falls off towards the edges. At any point on the plate, the illumination is proportional to the fourth power of the cosine of the angle between a line joining that point to the lens and the axis of the lens. Figures are given under WIDE-ANGLE LENS.

Coupled Exposure-Meter. An exposure-meter the mechanism of which is linked to the controls adjusting stop and shutter-speed. There are numerous forms, differing in detail, but in one usual type there is a pointer which can be moved to coincide with the needle of the exposure-meter by altering stop or shutter-speed, or both. When pointer and needle are brought together, the camera is correctly set for exposure.

Coupled Rangefinder. A rangefinder (*q.v.*) the mechanism of which is linked up with the focusing adjustment of the camera in such a way that the action of finding the distance of an object also focuses the camera upon that object.

Cover Glass. The name given to the piece of plain glass placed over the film side of a lantern slide, and bound up with it to protect it from scratches, etc. Also the piece of plain

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thin glass used as a cover for the object on a microscope slide. (See LANTERN SLIDE.)

Covering Power. See *Field of a Lens*, under LENS.

Cracked Negative. See BROKEN NEGATIVES.

Critical Angle. When light passes from a dense medium to a rare medium under an increasing angle with the perpendicular, an angle will be reached at which the refracted ray should make an angle of 90° with the normal. This is called the critical angle, past which internal or total reflection sets in.

Cropping. American term for what the British call trimming.

Crossed Nodes. Nodes (see LENS) so disposed that the node of admission is nearer to the image than is the node of emission. The nodal space is then negative, and is included both in the object-lens distance and in the lens-image distance.

Cross Front. A sideways sliding movement of the lens is provided on many cameras intended to be used chiefly on a stand. It is valuable for such purposes as centring the image in close-up work, and if the camera has to be turned on its side the cross front becomes a rising front (*q.v.*).

Crystal Varnish. This is specially designed for varnishing lantern slides and transparencies, and is made by dissolving 1 part of gum dammar in 18 parts of benzene.

Another formula for crystal varnish is :—

Canada balsam	5 parts
Shellac (yellow)	160 parts
Sandarac	170 parts
Alcohol	1000 parts

Crystoleum. An old form of coloured photograph prepared by transferring an albumen print to glass, usually convex in shape, rubbing off the paper support, and colouring the back of the print. In the days of albumen printing crystoleums were very popular, and some few may even now survive. With modern facilities a result of this type could probably best be made by using Transferotype (*q.v.*) or similar paper and transferring the image to glass, subsequently colouring it as desired. The original picture supplies all the fine shading, and anyone with the least knowledge of mixing

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and applying colours should be able to obtain very pleasing results.

Cubic Centimetre. A metric liquid measure, now legally replaced by the practically identical millilitre, which is one thousandth part of a litre. The equivalent of either in British measures is 16·9 minims, or about one-twenty-eighth of a fluid ounce. (See WEIGHTS AND MEASURES.)

Curvature of Field. When the image of a flat object, though sharp, falls on a curved surface, the lens is said to suffer from curvature of field. In most cases the sharp image is saucer-shaped in form, so that to get the edges of the picture sharp less camera extension is required than to focus the centre. By focusing between the positions found best for central and marginal definition respectively, and then stopping down sufficiently to give the required sharpness at centre and edges, the best result that can be had from a lens with curved field is obtained. (See also LENS.)

Curvilinear Distortion. See DISTORTION.

Cut Film. A form of film that is used, in a plate camera, as an alternative to plates. The celluloid base is much stouter than that used for roll or pack films, and cut films are sold, packed much like plates, in all the standard sizes in which plates are made. To bring the thickness up to that of a glass plate, it is common practice to back up each film with a piece of black card before putting it into the dark slide, or, better, to use a cut-film sheath.

Cyanine (Fr., *Cyanine*, or *Bleu de quinoléine ;* Ital., *Cianina ;* Ger., *Cyanin*, or *Chinolinblau*). Synonyms : Cyanine, Cyanin Iodide, Quinolin (or Chinolin) Blue. $C_{28}H_{35}N_2I = 525$.

Earliest known member of the class of cyanine dyes, a very large number of which have now been synthesized. The great majority of dyes used for sensitizing emulsions to various colours (see COLOURSENSITIVE EMULSIONS) belong to the cyanine class. Their chemistry is highly complex ; for a summary and bibliography of it see Chap. 11 of *The Theory of the Photographic Process*, by C. E. K. Mees.

Cyanotype. Synonyms : Negative Cyanotype, Ferroprussiate, or Blue Process. A process invented in 1842 by Sir John Herschel. It is called negative cyanotype because it produces copies of engineers' or architects' plans with white

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lines on a blue ground, the action being the reduction of a ferric salt by light to the ferrous state, followed by the precipitation of Turnbull's blue by the action of potassium ferricyanide.

The formulæ below, though giving a slower paper than that used by engineers, yield excellent copies of drawings; in addition, paper sensitised as described is capable of yielding very presentable half-tone prints from any fairly contrasty photographic negative. The two give prints of nearly identical characteristics in most respects.

A.	Potass. ferricyanide . . .	70 gr.	(8 gm.)
	Ferric ammonium citrate (*green*) .	158 gr.	(18 gm.)
	Water to	2 oz.	(100 c.c.)
B.	Potass. ferricyanide . . .	44 gr.	(5 gm.)
	Ferric ammonium citrate (*brown*) .	83 gr.	(9·5 gm.)
	Water to	2 oz.	(100 c.c.)

B gives slightly more contrasty prints than A, but paper prepared from the latter prints much more rapidly and yields a brighter blue. Either solution should be freshly prepared, and should be quite clear. Extra contrast can be obtained by adding a small amount of potassium bichromate to either formula.

The sensitising solution is spread over well-sized paper with a pad or brush, working in one direction, and then across to even the marks out. The paper is then hung up to dry, and appears of a greenish-yellow colour; and where the light acts on it it turns blue. After exposure it is merely washed in water, when the image becomes bright blue, and the ground, or unexposed portion, should remain quite white. The last wash-water should contain a few drops of hydrochloric acid.

Over-printed proofs may be reduced, after thoroughly washing, by being dipped in a weak solution of ammonia or a 2 per cent. solution of sodium carbonate, well washing, and then dipping into weak hydrochloric or acetic acid and well washing. Under-printed proofs may be intensified by immersion in a solution of ferric chloride, nitrate, or sulphate, 3·5 parts to 1000 parts of water, till the image appears darker in colour, and then well washing. Corrections, or taking out spots, etc., can be effected by touching the dry prints with a 4 per cent. solution of potassium oxalate, with which also titles may be written; and if red aniline ink be added to the above, or 4 parts of oxalate be dissolved in 100 parts of the red ink, the title will appear red on the blue ground.

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Cyanotype

Positive Cyanotype, or Pellet's Process

This process, which is only suitable for line results, depends, like the last, on the reduction of a ferric to the ferrous salt state by the action of light. In this process, however, a ferrocyanide, which gives Prussian blue by combining with the unchanged ferric salt, is used as developer. Exposed under a line drawing, the image given is of blue lines on a white or nearly white ground.

Pizzighelli in 1881 gave good working formulæ for this process :—

I.	Gum arabic	20 parts
	Water	100 parts
II.	Ferric ammonium citrate . .	50 parts
	Water	100 parts
III.	Ferric chloride	50 parts
	Water	100 parts

The two latter solutions will keep several weeks. The solutions are mixed in the following proportions *and order* :—

Solution No. I.	20 parts
Solution No. II.	8 parts
Solution No. III. . . .	5 parts

As soon as mixed this solution is thin, then becomes thick and cloudy, and then clear and liquid again, when it is ready for use. Well-sized paper is evenly coated with this solution with a broad brush, and the coating evened out with another brush. It must be quickly dried in a warm room, and protected from damp and light. In printing, the image appears as yellow on a darker ground. The developer is a 20 per cent. solution of potassium ferrocyanide, which should be spread over the proof with a broad brush, care being taken that no solution touches the back of the paper or stains will be produced. Alternatively, the print may be floated, face down, on the solution.

As soon as the image appears of a deep blue colour, the print should be well washed, and then laid in 10 per cent. hydrochloric acid till the ground appears white ; and the print should then be well washed and dried.

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D

D.A. Abbreviation for " delayed action," which see.

Daguerreotype. An early process for obtaining a camera picture; invented by Daguerre. A sensitive surface of silver iodide and bromide was formed by exposing a silvered copper plate to the direct action of the halogens. After exposure, which was inordinately prolonged, the development was effected by exposing the plate to the vapour of metallic mercury, which was deposited on the plate as an amalgam of silver and mercury. The unacted-upon iodide and bromide were then dissolved by potassium cyanide or by hypo, and the image toned by sel d'or. (See GOLD THIOSULPHATE.) The first intaglio photogravures were made by Mr. Justice Grove in 1840, by the electrolytic etching of the daguerreotype plate. The plates were too shallow to give good prints.

The fullest practical details of the process can be found in " The History and Practice of Photogenic Drawing," by L. J. M. Daguerre, translated by Dr. J. S. Memes (London: 1839, Smith, Elder & Co.). Another informative account of the process and of Daguerre's early work is to be found in Tissandier's " History and Handbook of Photography," by J. Thompson, London, 1876 (Sampson Low & Co.).

Cleaning and Copying Daguerreotypes.

As many daguerreotypes are still in existence, and are frequently to be found in a tarnished or otherwise damaged condition, the following instructions for cleaning and copying them will be found useful:—Carefully remove the daguerreotype from its frame and separate from its covering glass, and place face upwards in a dish of cold water. Be extremely careful not to touch the front of the plate, as the slightest touch will leave a permanent mark. Lift the plate by the

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corners and remove the paper from the back when sufficiently soaked ; rinse the plate thoroughly, and, should the water be repelled as though the plate were greasy, flow over it a little methylated spirit. If the tarnish on the edges be blue in colour, immersion in an ordinary fixing bath will remove it ; but if any bronzing is visible, make a solution of potassium cyanide, ten grains to the ounce, and keep pouring this on and off till all tarnish is removed. Wash the plate thoroughly to free from cyanide, and rinse well with distilled water ; then take hold of one corner of the plate with a pair of pliers, and dry evenly from a top corner downwards over a spirit lamp or Bunsen burner. If any stain or deposit is left by unequal drying, the plate must again be rinsed with distilled water, and dried in the same way. The chief point is not to touch the plate with anything but the liquids, or a mark will be made which nothing will eradicate. To copy a daguerreotype the best plan will be to place it inside a deep box, lined with velvet or black cloth, with a hole in the lid for the lens to peep through, and a piece cut out of one side only to illuminate the plate by—sunshine is best, though the light from an enlarging lantern is equally effective. In most daguerreotypes the marks of the buffer are seen as fine horizontal lines. In copying, these should be placed vertically, and when in that position are barely visible.

D. and P. An abbreviation for " Developing and Printing " referring to the service offered by firms who undertake the developing and printing of negatives for amateurs.

Dark Corners. See WIDE ANGLE.

Dark-Room. Room used for photographic work, and which can be darkened completely when required. Complete exclusion of light is not essential for users of roll film if they possess a developing tank of the type that can be loaded in daylight, but for users of plates, cut films, or film packs it is required for transferring the sensitive material from the dark-slide or adapter to the developing tank and, except in the case of film packs, is also needed for loading the slides. Many tanks for roll film also require to be filled in darkness, though the actual development may be conducted in full light.

A dark-room of some sort, even if only a temporarily converted bath-room or scullery, is an essential to every photographer who aspires to produce enlargements.

Although there are many ways of converting a bath-room

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to photographic use, the simple storage cupboard and work-bench combined of Fig. 1 is suitable in nearly every case.

The dark-room is lighted with a " safe light " (*q.v.*), which may take the form of a lamp or lantern illuminated with artificial light (gas, oil, electric light, etc.), and with as large an opening in front as may be, in which is held a " safelight screen " designed for the sensitive material in use. These are supplied by several manufacturers, the usual sizes being 7 × 5 in., 10 × 8 in., and 12 × 10 in., and consist of two

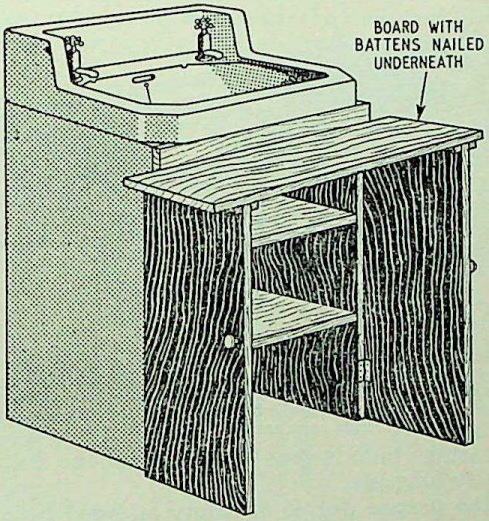

FIG. 1. The space beneath a bathroom basin, if boxed in, and fitted with shelves if desired, provides useful storage for bottles and dishes. As shown, the doors may be made the supports of a convenient work-bench.

sheets of glass between which is a layer of gelatine or paper dyed to the tint correct for the intended purpose. This coloured light should be the only illumination proceeding from the lamp; all other openings for ventilation, etc., being trapped. A lamp capable of giving red light only is not ideal; the modern worker generally handles plates and films in complete darkness, and uses his lamp only for enlarging, for which a bright orange-yellow or yellow-green light is required. The

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most generally useful type of lamp is that fitted for interchangeable " safe-lights " (*q.v.*).

As only a small amount of light is required, and deficiency in blue is no drawback, bulbs for the dark-room lamp should be rated for a voltage higher than that with which they are to be used. At the same time, the wattage-rating should be higher than that recommended for the safelight in use. The fragility

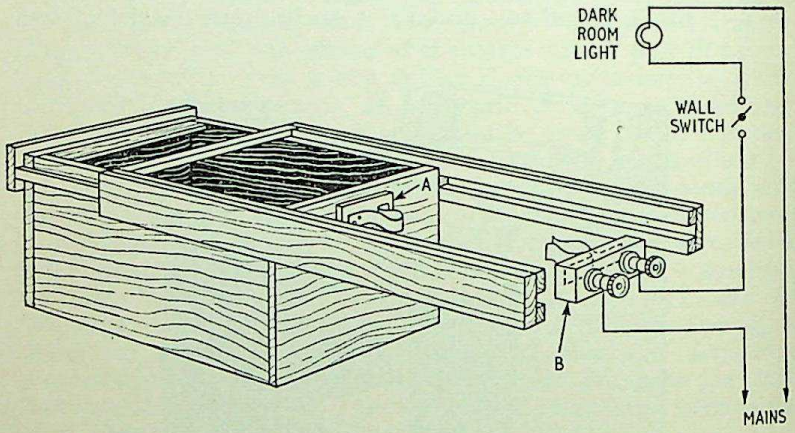

FIG. 2. Safety storage-box for papers. This may be fitted below the table or work-bench in any permanent dark-room, and enables paper to be found quickly without perpetual wrapping and unwrapping. By fitting an electrical contact wired in series with the white light, this is made to go out automatically before the drawer opens, so protecting the contents from accidental fogging.

of a low wattage bulb is thus avoided, and the bulb will have an extremely long life.

Unless the precise degree of safety afforded by a safe-light is specified by the manufacturer, the light should always be tested before a new dark-room lamp is taken into use. (See SAFELIGHT, TO TEST.) Remember that any light will cause fog if the sensitive material is held close enough to the lamp for a sufficient time.

The dark-room should include a shelf or table on which to develop. This should be of a convenient height, to allow the operator to sit at his ease whilst developing. It should be covered with some non-absorbent material, such as sheet lead or zinc, and the edge of this should be turned up about a quarter of an inch to prevent any solution which might be spilt from running over. Alternatively, the wood may be waxed, using a solution of paraffin wax in xylene, or may be

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covered with linoleum or American cloth. A marble-topped washstand also makes an excellent developing bench, but is rather readily pitted by acids. There should also be a sink, with a tap and a good supply of water. Shelves should be placed at convenient heights for the storing of bottles, printing frames, boxes, etc. The safety storage-box for papers shown in Fig. 2 is a great convenience when printing or enlarging. The room and developing table should be kept scrupulously clean, and after operations all solutions spilt and the trays, measures, etc., should be cleaned and put away. (See *Waterproofing Work Bench*, under BLACKING.)

There are many objections to the ordinary system of a dark-room door with a bolt on the inside, but when the door

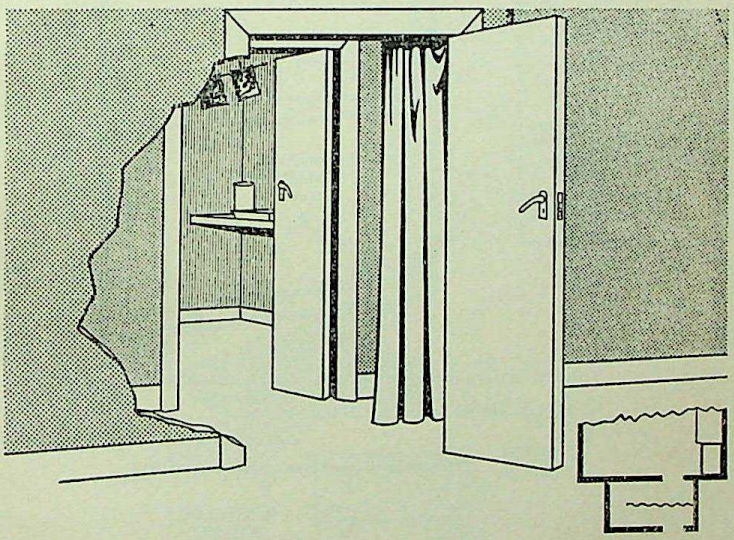

FIG. 3.

opens directly to a fully lighted place, the inside bolt is absolutely necessary as a protection to the user of the room. Fig. 3 indicates a satisfactory form of entrance through a vestibule divided by a hanging curtain of dark material. The curtain must fit closely at the top, also at one end, and the inside of the vestibule should be distempered dull black.

Every dark-room should be provided with an inlet for fresh air and an outlet for foul air. Fully light-trapped ventilators

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that can be inserted in holes in door, partition, or wall are available as commercial articles. If the room has a double sash window, the inlet can be easily made by temporarily fixing a strip of wood the length of the window on the framework under the bottom sash. The edges should be bevelled so as to make a neat fit when the lower sash is down. This will

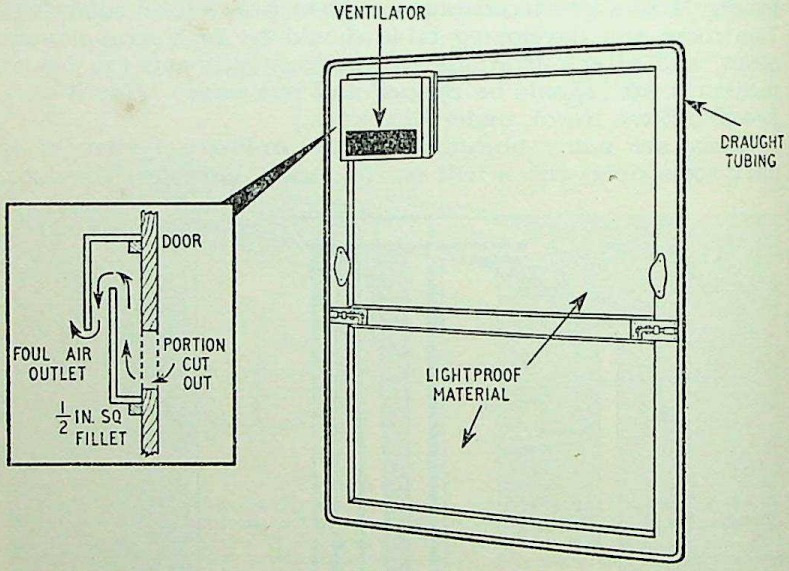

FIG. 4. Suggested design of frame for obscuring window. The inset is a section of the ventilator showing method of light-trapping.

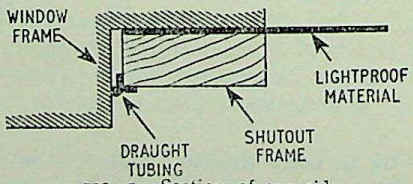

FIG. 5. Section of one side of the shutter shown in Fig. 4.

leave a small cavity for the entrance of fresh air between the glass of the top and lower sashes.

An excellent way of freeing the room of foul air is to fix into the outside wall a 10-in. square perforated earthenware air-

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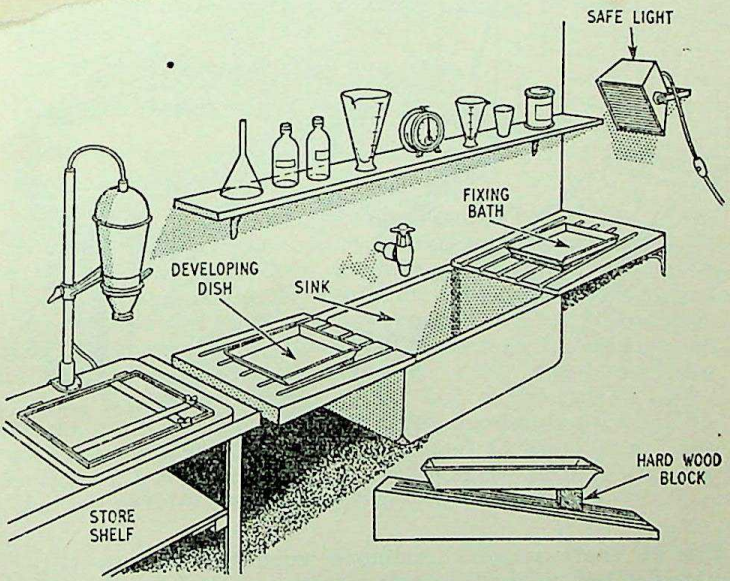

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exposures on bromide or gaslight papers or plates. It is to be noted that the luminous paint often used on the dials of watches or clocks emits light enough to fog a highly sensitive

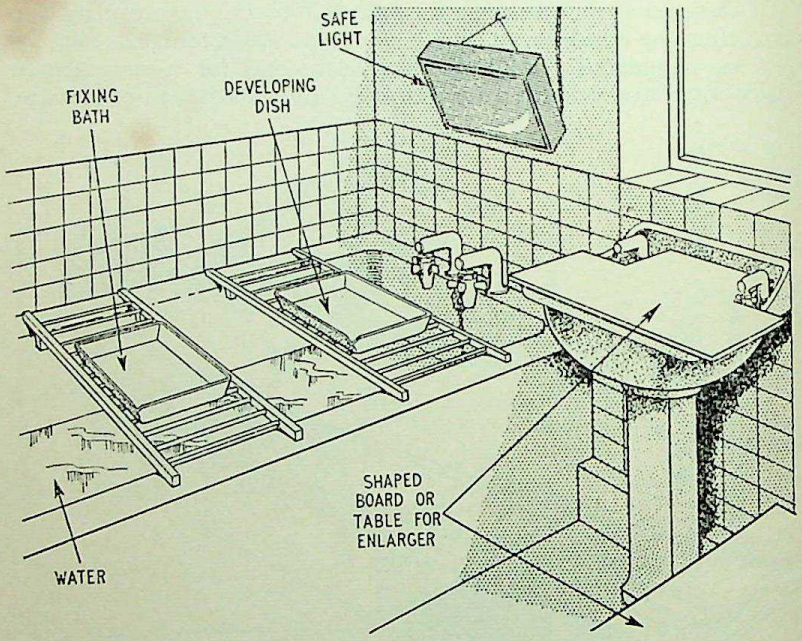

FIG. 7. Suggested dark-room layout for a converted bathroom.

film at short range. Luminous wrist-watches are better discarded before handling fast sensitive material.

(See also TIMERS and PENDULUM.)

Dark-Room Light. See SAFELIGHT and DARK-ROOM.

Dark Slide. This is the term used for the holder of the sensitive plate or cut film, and is inserted in the back of the camera, replacing the ground-glass screen. Double dark slides, which are usually of wood, may be book-form, *i.e.*, open like a book, one plate being placed in each side, or " solid," in which the two plates, with an opaque septum between, are inserted either from the front or through an opening at one

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end. Single slides are usually made of stamped metal. They hold one plate each, which is inserted by withdrawing the front shutter (also of thin metal) and placing the plate, film side up, inside. It is then held firmly in position by a spring clip. The shutters of wooden double slides are sometimes hinged, so that they can be folded back out of the way when the slide is in the camera. The solid form in most cases is fitted with " pull-out " shutters of thin metal. Care should always be taken when replacing these to insert them squarely in the opening. If replaced cornerways, the light-trap in the top of the slide may be opened sufficiently to admit a streak of light and fog the plate.

Daylight Enlarging. See ENLARGING.

Daylight Spools. See FILMS.

Deci-. Prefix used in the metric system (*q.v.*) to signify " one-tenth of."

Definition is the accurate concentration by the lens of the light from a point in an object to the corresponding point in its image without spreading to adjacent parts. It can be expressed numerically by a figure for the extent of this spread —*i.e.*, the diameter of the circle of confusion (*q.v.*). Perfection of definition depends on the design of the lens, the accuracy of its manufacture, the accuracy with which the lens-to-film distance is adjusted in the camera, and in the case of a film camera, on the exactitude with which the film lies flat and in the focal plane. The type of film, and to some extent the developer, used also have a considerable bearing on the definition of the finished negative. (See also LENS.)

Deka-. Prefix used in the metric system (*q.v.*) to signify " ten." For example, a dekagram is 10 grams.

Delayed Action. Many shutters on modern cameras, particularly those of the " Compur " and " Prontor " types, are now made with a " delayed action " adjustment. When these are employed, the shutter can be set as usual, and after a lapse of a certain period (generally 10-15 sec.) the shutter automatically opens and closes at the speed to which it has previously been set. By this means it is possible for the photographer to set the shutter and then take his place in a group or even in a view so that he is included in the picture. Delayed action devices are also made as separate accessories.

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These contain a simple clockwork mechanism that slowly depresses the plunger of the wire release, on the end of which they are hung. Yet another model simply screws into the cable release socket of the shutter.

Deliquescence. The liquefaction of a highly soluble salt by the absorption of water from the atmosphere.

Densitometer. An instrument for measuring the density of any selected part of a film or plate. In the most usual type the intensity of a beam of light passing through the density to be measured is compared with that of a second beam the intensity of which is controllable by means of an iris diaphragm or an optical wedge. Comparison may be visual or by means of photoelectric cells. For determining the density of an image on paper, a reflection densitometer is used.

For a full discussion, with bibliography, see Chap. 20 of *The Theory of the Photographic Process*, by C. E. K. Mees. (Macmillan.)

Density. For sensitometric purposes density is defined as the logarithm of the opacity (see SENSITOMETRY). In everyday parlance it is common to speak of the density of the negative as a whole, and while the meaning of the term in this connection is evident enough, it is not susceptible of precise definition. A dense negative is one of which all parts have high opacity; it is the result of an exposure considerably in excess of the minimum correct exposure. Its opposite, a "thin" negative, is generally due to under-exposure, though it may also be due to under-development. A contrasty negative is often spoken of as "dense"; there is, however, no necessary connection between density and contrast, and the two should be sharply distinguished.

Depth of Focus. Strictly, means range of movement of lens that is permissible before image of object focused upon becomes noticeably unsharp. (See *The Accuracy Required* under FOCUSING SCALE.) More usually applied to range of distances over which an object can move without becoming noticeably unsharp, the focusing of the camera being considered fixed. In this sense, in which it is understood here, synonyms are "Depth of Field" and "Depth of Definition."

If a camera is focused upon some definite distance, objects a *little* nearer or a *little* further away will not be shown on the film as noticeably less sharp than that actually focused upon,

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but objects *much* nearer to the camera, or *much* further away, will be very obviously unsharp. The depth of focus covers the range of distances, more or less centred on the distance actually focused upon, within which definition can be accepted as sharp enough. It is therefore evident that the range of depth of focus depends on the standard of definition set, as well as upon the optical characteristics of the lens.

The standard of definition to be taken as the minimum acceptable, which settles the range of depth in any particular case, is defined in terms of the permissible circle of confusion (*q.v.*). Practical choice of a standard is discussed under HYPERFOCAL DISTANCE, to which article reference should be made before reading further.

Depth of focus is most easily found by first determining the hyperfocal distance that corresponds, for the lens and stop in use, to the standard of definition required. When focused on infinity, the nearest object sharply rendered is at the hyperfocal distance H; when focused on H, depth covers the range from infinity to one-half of H. This series can be extended indefinitely; if we divide the hyperfocal distance by 2, 3, 4, 5, etc., in succession, we obtain a series of distances such that if the camera is focused on any one, depth extends to the next on either side. If for any particular lens and stop the hyperfocal distance H is 120 ft., the series is Inf., 120, 60, 40, 30, 24, 20, etc. When the camera is focused on 120 ft., depth extends from 60 ft. to infinity; focused on 60 ft., from 40 to 120 ft., and so on down the series.

Focusing scales are not often marked with so logical and convenient a series of distances as this, but we can nevertheless make use of the series to provide a rule that often allows a quick estimate of depth to be made without reference to a table. If H = 80 ft., and the lens is focused for 9 ft., it is evident that the distance focused on is nearly enough one-ninth of H. Depth extends from one-eighth to one-tenth of H; *i.e.*, from 8 to 10 ft. The calculation is both accurate and easy when H happens to be an exact multiple of the distance focused upon. When it is not, remember that the value of H depends, after all, on an arbitrary decision as to what we shall call "sharp," and revise H mentally to suit the needs of the moment. If H has been worked out as 56 ft., and we focus on 15 ft., then this is evidently about one-quarter of H. Take H as four times 15, or 60 ft.; depth will extend from H/3 to H/5, or from 20 ft. to 12 ft.

Another, but less accurate, means of rapidly estimating

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depth is as follows. If the distance focused on is, say, one-tenth of H, then depth will extend, each way, to approximately one-tenth of the distance focused upon. If H = 60 ft., and the camera is focused on 5 ft., (equals one-twelfth of 60 ft.), depth then extends 5 in. (equals one-twelfth of 5 ft.) on either side of this distance. This rule ceases to be serviceable when focusing on distances greater than a quarter or a third of H. It is particularly valuable, therefore, for close-up subjects, in connection with which the error is small. But it should be observed that no rule professing to give one figure for the depth on the two sides of the distance focused upon can ever be strictly accurate, as there is always more depth beyond that distance than on the near side of it.

For all but very near objects, the following formula allows depth of focus to be calculated for any distance. If D is the distance focused upon, then the nearest object sharp will be at a distance $\frac{HD}{H + D}$ from the lens, and the furthest object sharp at a distance $\frac{HD}{H - D}$. D and H must of course be measured in the same units.

Example. For a lens of hyperfocal distance 60 ft., focused on 10 ft., the nearest distance sharp is $\frac{60 \times 10}{60 + 10} = \frac{600}{70} =$ 8·57 ft., or 8ft. $6\frac{3}{4}$ in.

The furthest distance sharp will be $\frac{60 \times 10}{60 - 10} = \frac{600}{50} = 12$ ft.

The standard of sharpness at these limits is of course that set by the value of H ; that is, it is the same as that with which an object at 60 ft. is rendered when the camera is focused on infinity.

Depth of focus is controlled by three factors : the focal length of the lens in use, the stop at which it is used, and the distance of the object. When faced, in practice, with a subject covering a considerable range of distances from the camera, the required depth can be obtained (*a*) by exchanging the lens in use for one of shorter focal length, (*b*) by stopping the lens down, or (*c*) by retreating to a greater distance from the subject.

In most cases solution (*a*) is not practicable, and in everyday work solution (*b*), stopping the lens down, is used to furnish the required depth of focus. Where, however, the subject is liable to move rapidly, or the light is very weak, so that the

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use of a stop small enough to provide the required depth will lead to subject-movement or to under-exposure, the third solution, that of retreating from the subject, must be resorted to. The practical rule is simple ; even allowing for the extra sharpness needed to compensate for the extra enlargement the smaller image will require, depth will remain unchanged so long as the product of distance and f-number remains unchanged. Thus if the object is at 10 ft. and f/8 has to be used to give the required depth, at 14 ft. f/5·6, at 20 ft. f/4, or at 28 ft. f/2·8 can be used, and the required depth of focus will still be given.

The depth of focus table on pages 188 and 189 gives the near and far limits of depth, over a great range of focusing distances, for lenses having hyperfocal distances from 10 feet to 500 feet. To use this table, it is first necessary to determine the hyperfocal distance, for each stop, of the lens in use. (See HYPERFOCAL DISTANCE, in which article a table of hyperfocal distances will be found.) Above the zig-zag heavy line the table shows, in feet and inches, the distances from the camera of the nearest and furthest object sharply rendered. Below that line the table gives the extent of depth measured, in inches, *outward from the point focused on.* Thus when focusing on an object 5 feet away with such a lens and stop that the hyperfocal distance is 50 feet, depth extends from a point 6.3 inches further from the camera than the object focused on, to a point 5.2 inches nearer to the camera than that object.

Refer also to *Depth of Focus* by Arthur Cox (Focal Press.)

More Advanced Formulæ

The formulæ for depth already given are amply accurate enough for all ordinary practical purposes, but the more advanced student should realise that they are approximate only. The exact forms are :

$$\text{Near Limit of Depth} = \frac{HD}{H+(D-f)}$$

$$\text{Far Limit of Depth} = \frac{HD}{H-(D-f)}$$

For objects so near that $(D-f)$ is notably different from D, these exact formulæ should replace those given earlier. All distances are to be measured from the node of admission of the lens.

The limits of depth can also be worked out without first finding H. If c is the permissible diameter of the circle of confusion, and n the f-number of the stop, near and far limits respectively are:

Hyperfocal Distance in Feet

Focused on:	10	15	20	25	35	50	65	80	100	120	150	200	250	350	500
100 ft.	Inf. 9–1	Inf. 13–3	Inf. 16–8	Inf. 20	Inf. 26	Inf. 33	Inf. 40	Inf. 45	Inf. 50	600 55	300 60	200 67	167 72	140 78	125 84
50 ft.	Inf. 8–4	Inf. 11–6.	Inf. 14–3	Inf. 16–9	Inf. 21–6	Inf. 25	215 28	132 31	100 33	85 35	75 38	66 40	62 42	58 44	55–6 45–6
40 ft.	Inf. 8–0	Inf. 10–11	Inf. 13–5	Inf. 15–6	Inf. 18–9	195 22	103 25	80 27	66 29	60 30	54 32	50 33	47–6 34–6	45 36	43–6 37
30 ft.	Inf. 7–6	Inf. 10–0	Inf. 12–0	Inf. 13–8	200 16–3	74 18–9	55 21	48 22	43 23	40 24	37 25	35 26	34 26–9	32–9 27–6	32 28–3
25 ft.	Inf. 7–2	Inf. 9–5	Inf. 11–0	Inf. 12–6	85 14–9	49 16–9	40 18–0	36 19–0	33 20	31 21	30 21–6	28–6 22–3	27–9 22–9	27–0 23–3	26–3 23–9
20 ft.	Inf. 6–8	Inf. 8–7	Inf. 10–0	95 11–0	46 12–9	33 14–3	29 15–3	27 16–0	25 16–9	24 17–3	23 17–6	22–3 18–3	21–9 18–6	21–2 18–11	+9·8 −9·1
18 ft.	Inf. 6–6	Inf. 8–3	160 9–7	62 10–6	36 12–0	28 13–4	25 14–3	23 14–9	22 15–3	21–0 15–9	20–6 16–0	19–9 16–7	19–4 16–10	+11·5 −10·4	+8·0 −7·4
15 ft.	Inf. 6–0	Inf. 7–6	57 8–8	36 9–5	26 10–7	21–3 11–6	19–6 12–3	18–6 12–9	17–6 13–0	17–0 13–3	16–8 13–8	16–2 14–0	+11·3 −10·0	+7·9 −7·3	+5·5 −5·2

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Hyperfocal Distance in Feet (*Continued*)

Focused on:	10	15	20	25	35	50	65	80	100	120	150	200	250	350	500
12 ft.	Inf. 5–5	55 6–8	29 7–7	22–6 8–9	18–0 9–0	15–9 9–9	14–6 10–3	14–0 10–6	13–6 10–9	13–3 11–0	+12·2 −10·5	+9·0 −8·0	+7·1 −6·5	+5·0 −4·7	+3·4 −3·3
10 ft.	49 5–1	28 6–1	19–6 6–9	16–6 7–1	13–9 7–10	12–6 8–4	11–9 8–8	11–6 8–11	+12·9 −10·7	+10·6 −9·0	+8·3 −7·3	+6·1 −5·6	+4·8 −4·5	+3·44 −3·25	+2·39 −2·29
8 ft.	36 4–6	16–6 5–3	13–0 5–9	11–7 6–1	10–3 6–7	9–6 6–11	+13·0 −10·2	+10·3 −8·5	+8·1 −6·9	+6·6 −5·8	+5·2 −4·7	+3·8 −3·6	+3·1 −2·9	+2·17 −2·08	+1·51 −1·47
7 ft.	21–6 4–2	12–9 4–10	10–6 5–3	9–7 5–6	8–8 5–10	+13·1 −10·0	+9·8 −7·9	+7·8 −6·5	+6·1 −5·3	+5·0 −4·5	+4·0 −3·6	+2·9 −2·7	+2·3 −2·2	+1·65 −1·59	+1·15 −1·12
6 ft.	14–0 3–10	9–9 4–4	8–5 4–8	7–10 4–10	+14·1 −10·2	+9·4 −7·4	+7·0 −5·9	+5·6 −4·8	+4·4 −3·9	+3·6 −3·3	+2·9 −2·7	+2·1 −2·0	+1·69 −1·62	+1·20 −1·16	+0·84 −0·82
5 ft.	9–6 3–5	7–4 3–10	+18·7 −11·5	+14·1 −9·6	+9·4 −7·2	+6·3 −5·2	+4·7 −4·1	+3·8 −3·4	+3·0 −2·7	+2·5 −2·3	+1·96 −1·84	+1·46 −1·39	+1·16 −1·12	+0·83 −0·80	+0·58 −0·56
4½ ft.	7–10 3–2	+21 −11·9	+14·6 −9·5	+11·1 −7·8	+7·5 −5·9	+5·0 −4·2	+3·8 −3·3	+3·0 −2·7	+2·4 −2·2	+1·97 −1·85	+1·58 −1·49	+1·17 −1·12	+0·93 −0·90	+0·66 −0·65	+0·46 −0·45
4 ft.	6–5 2–11	+16·0 −9·6	+11·1 −7·6	+8·5 −6·3	+5·8 −4·7	+3·9 −3·4	+2·9 −2·6	+2·4 −2·1	+1·9 −1·7	+1·55 −1·45	+1·23 −1·17	+0·92 −0·88	+0·73 −0·71	+0·52 −0·51	+0·36 −0·36
3½ ft.	+20 −10·3	+11·6 −7·5	+8·2 −5·9	+6·3 −4·8	+4·3 −3·6	+2·9 −2·6	+2·2 −2·0	+1·8 −1·6	+1·4 −1·3	+1·17 −1·11	+0·93 −0·89	+0·69 −0·67	+0·55 −0·54	+0·39 −0·39	+0·27 −0·27
3 ft.	+13·7 −7·8	+8·1 −5·6	+5·7 −4·4	+4·5 −3·6	+3·1 −2·6	+2·1 −1·9	+1·6 −1·5	+1·3 −1·2	+1·02 −0·96	+0·84 −0·81	+0·67 −0·65	+0·50 −0·49	+0·40 −0·39	+0·28 −0·28	+0·20 −0·20

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Depth of Focus

$$\frac{Df^2}{f^2+nc(D-f)} \text{ and } \frac{Df^2}{f^2-nc(D-f)}.$$

Note that as D approaches infinity, the near depth approaches a limit equal to $f^2 \div nc$; this gives the fundamental formula for hyperfocal distance.

If preferred, depth may be measured outwards from the object focused upon. It extends towards the camera for a distance $\frac{ncD(D-f)}{f^2+nc(D-f)}$ and away from it for a distance $\frac{ncD(D-f)}{f^2-nc(D-f)}$. Note that the latter distance is in all cases greater than the former.

These distances also may be expressed in terms of H; they are respectively $\frac{D(D-f)}{H+(D-f)}$ towards the camera, and $\frac{D(D-f)}{H-(D-f)}$ away from it.

Special Note. When focusing is done by front cell or supplementary lens, replacing $(D-f)$ in all above formulæ by D gives, not an approximation, but exact formulæ in every case.

Obtaining Pre-determined Depth.—If the distances from the camera of the nearest and furthest objects required to be included are P and Q, then to render these objects at equal sharpness on the film the focusing scale must be set to a distance D such that $D = \frac{2PQ}{P+Q}$. It is to be noticed that on a normal focusing scale the correct setting is found by placing the pointer half-way between the scale-marks corresponding to P and Q.

If P and Q are respectively 10 and 20 ft., D will be 13⅓ ft. If the scale is marked for 10, 15 and 20 ft., the 15 ft. mark will not be midway between the other two, but will be nearer the 20 ft. mark. It is the (unmarked) halfway point between 10 ft. and 20 ft. marks that is the correct setting for D.

This assures equal sharpness for P and Q; the absolute value of the sharpness depends on the *f*-number *n*. For a circle of confusion *c* on the negative, the stop required is given approximately by :—

$$n = \frac{(Q-P)f^2}{2\,PQc}$$

Where *f* is the focal length of the lens in use. If, for the case given above, a lens of focal length 3 in. were in use, and the circle of confusion to be permitted on the negative were 1/300th inch, then, since Q = 20 ft. = 240 in. and P = 10 ft. = 120 in., we get

$$n = \frac{(240-120)3^2}{2 \times 240 \times 120 \times \frac{1}{300}} = \frac{120 \times 9 \times 300}{240 \times 240} = \frac{2700}{480} = 5.6$$

Objects at the distances named are thus rendered with the required sharpness by focusing on 13 ft. 4 in., and stopping down to *f*/5.6.

The formula for D is exact, but the focusing setting is not quite exactly halfway between those for P and Q. In the case given, the halfway setting does not focus on 13⅓ ft., but on a point one-twentieth of an inch beyond it. The error is completely negligible, but to save confusion on the part

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of any who may wish to check the formula, it is worth recording that the halfway point focuses on a distance $2f^2 \div (P + Q)$ beyond D.

The formula for n is not exact; the denominator should read $2PQc - cf(P+Q)$. The additional term is small compared with $2PQc$.

It is of more practical value to point out that if c can be expressed, as it often can, as a fraction of f, the formula for n can be simplified. If the circle of confusion is to be one-thousandth of the focal length, we get:

$$n = \frac{1000f(Q-P)}{2PQ}$$

In the case above, this formula gives $f/6.3$, the small change in f-number corresponding to the change from 1/300th to 3/1000th inch in the circle of confusion.

Depth with Different Lenses

Various problems, of greater or less practical importance, arise in connection with depth of focus. In most cases they involve comparison of depth with lenses of different focal lengths. The advanced student will not find much difficulty in solving them provided he keeps a very clear picture of the basis upon which the comparison of depth is to be made. This is not always as easy as it sounds.

The simplest of these problems is that of comparing the depth of focus given by lenses of different focal length, it being assumed that all include the same angle of view (i.e., that the size of negative made is proportional to focal length) and that the basis of comparison for results is that enlargements of equal size, equal sharpness, and equal angle of view are to be made from all the negatives. On this basis it can easily be shown that for equal depth $f \div n$ must be constant; a 2-inch lens at $f/2$, a 4-inch lens at $f/4$, or a 6-inch lens at $f/6$, will all give the same depth.

As all these lenses have the same absolute diameter of one inch, this has led to the statement that depth depends only on the absolute diameter, and not on focal length or f-number. For the conditions specified, this is perfectly true; the simplicity of the rule, however, has led to the statement being put forward as a sweeping generality, and it has been applied to cases for which it is entirely incorrect. It is fallacious to apply it, for example, to the case where different lenses are used on a negative of constant size, making prints of equal sharpness and equal size, but with different angles of view. This corresponds to the case of the miniature with interchangeable lenses, or the ¼-plate reflex used with a telephoto lens. Here the condition for constant depth is that $f^2 \div n$ shall be constant. To equal the depth of a 2-inch lens at $f/2$, a 4-inch lens will now have to be stopped down to $f/8$, instead of only to $f/4$, as in the preceding case.

Another case of some practical importance is one that arises in connection with portraiture and similar work. Images of equal size can be had by working at 5 ft. from the sitter with a 5-inch lens, or at 10 ft. with a 10-inch lens. We know that depth is less with a long-focus lens; but then it is also less at near distances. Is the decreased depth associated with the long-focus lens compensated for in this case by the greater distance of the sitter? The analysis here is more complex, but the practical conclusion is that the depth given by the two lenses, assuming them to be used at the same f-number, is virtually identical, though the lens of shorter focal length does, on paper, give a shade more depth. This difference in

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depth, trifling when photographing relatively near objects, does not become practically appreciable until the distance of the object is increased to about a quarter or a third of the hyperfocal distance of the short-focus lens.

This practical identity of depth, however, does not always hold. Suppose the subject is a street scene, to be taken from a fixed view-point, and as the angle of view is narrow a 4-inch lens on a miniature will include all of the subject that is wanted. To get the requisite depth the lens has to be stopped down to *f*/8. If we substitute a 2-inch lens, what stop will be needed to give the same depth ? Here we have to remember that as the image of the required part of the subject will now be smaller on the film, it will also have to be sharper to stand the extra enlargement needed to give a finished print in all respects identical with that from a negative taken with the 4-inch lens. Will this need for extra sharpness nullify the extra depth of the short-focus lens?

This case is simply that first propounded above, where the angle of view is constant and the size of the negative (here the useful part of it) proportional to focal length. For constant depth $f \div n$ is constant, so the depth of the 4-inch lens at *f*/8 can be duplicated precisely by using the 2-inch lens at *f*/4.

Depth, Size and Speed.

Reference to formulæ and tables included in the article on hyperfocal distance, on which depth of focus depends, will show that even after allowing for the greater sharpness required on a small negative to permit of subsequent enlargement the hyperfocal distance is less, or the depth greater, on a small negative than on a large one. For the same angle of view in each case, the following table gives the lens-apertures, and consequent relative exposures, for negatives of various sizes, the stop being so adjusted in each case that when all negatives are enlarged to give the same size of final picture the depth of focus on all is the same. An aperture of *f*/8 on a ¼-plate camera is taken as a basis of comparison.

Size	Stop	Relative Exposure
24 × 36 mm.	*f*/2·5	1/250th sec.
4·5 × 6 cm.	*f*/4·4	1/80th sec.
3¼ × 2¼ in.	*f*/5·9	1/45th sec.
¼-plate	*f*/8	1/25th sec.
5 × 4 in.	*f*/9·6	1/17th sec.
6½ × 4¾ in.	*f*/12	1/11th sec.

The much wider lens-aperture, and consequent shorter exposure, permitted by the small camera when so adjusted as

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to give, on enlargement, prints completely indistinguishable from those from larger negatives, is the chief technical advantage of the miniature camera.

Depth of Focus Indicator. The focusing-scales of many modern cameras are fitted with a depth of focus indicator similar in principle to those on pp. 194-5. All are based on the fact that the range of distances over which satisfactorily sharp definition is maintained corresponds, at all parts of the scale, to a fixed movement of the lens with respect to the film.

The indicator-scales reproduced may be traced, mounted on card, and pivoted so that the stop-scale rotates within the scale of distances. If the arrow on the stop-scale is brought against the mark on the outer scale indicating the distance for which the camera is focused, the nearest and farthest distances in focus at that setting can be read off, for any stops, against the two figures for the stop in use.

Three stop-scales are provided, one for each of the focal lengths most commonly used by amateurs. In calculating the scales the focal length of the lens was assumed to be equal to the diagonal of the negative, and the standard of definition taken is $\frac{1}{100}$ in. circle of confusion on an enlargement of diagonal 9 in. (see HYPERFOCAL DISTANCE). For $h = 108$ (enlargement of diagonal $12\frac{3}{4}$ in.), take throughout one stop smaller than the indicator shows.

The most practical way of using the indicator is to find the nearest and farthest distances to be sharply rendered, and turn the stop-scale so that the central arrow falls between them. Then try to bridge the distances with a pair of identical stop-numbers. If this cannot be done with *f*/5·6, but can be done with *f*/8, set the lens to *f*/8, and finally adjust the stop-scale so that the two *f*/8 markings fall equally outside the two distances concerned, and set the focusing-scale as the arrow then indicates.

Desensitising and Desensitisers. A desensitiser is a substance which, when applied to a sensitive emulsion, reduces its sensitivity to light. Most desensitisers destroy, or partially destroy, the latent image on an exposed plate; those that do not are mostly dyes. These are of great value in permitting even the fastest and most colour-sensitive plate or film, after a short treatment in total darkness, to be developed in a comparatively bright yellow light.

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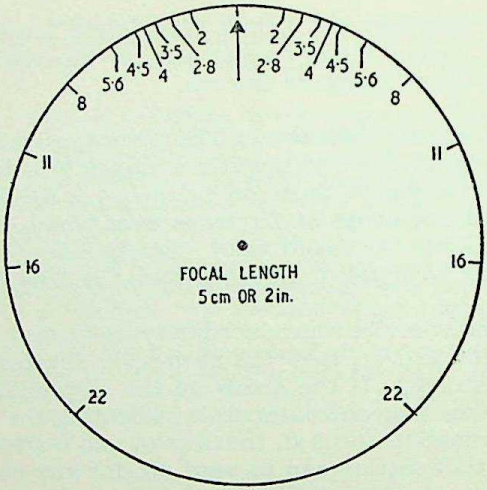

FIG. 1. Stop-Scale for 5 cm. lens (24 x 36 mm. or 3 x 4 cm. cameras).

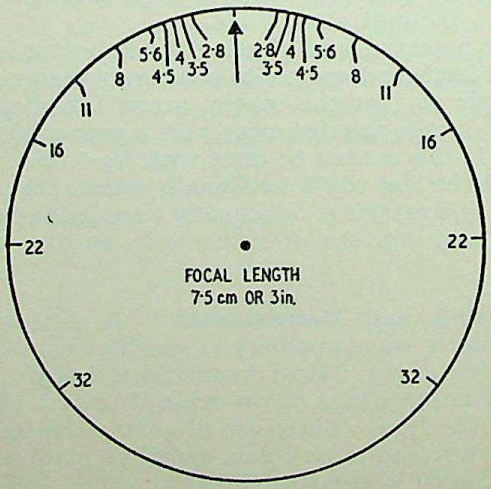

FIG. 2. Stop-Scale for 7·5 cm. lens (4·5 x 6 cm., or 6 x 6 cm. cameras).

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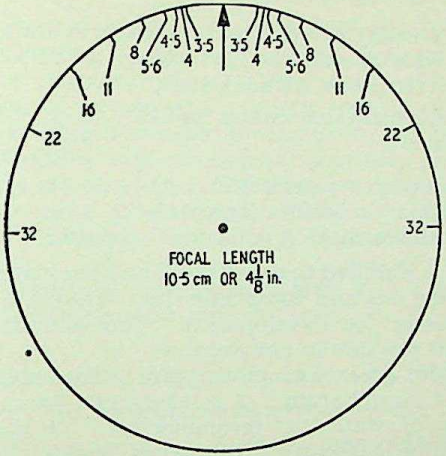

FIG. 3. Stop-Scale for 10.5 cm. lens ($3\frac{1}{4}$ x $2\frac{1}{4}$in. cameras).

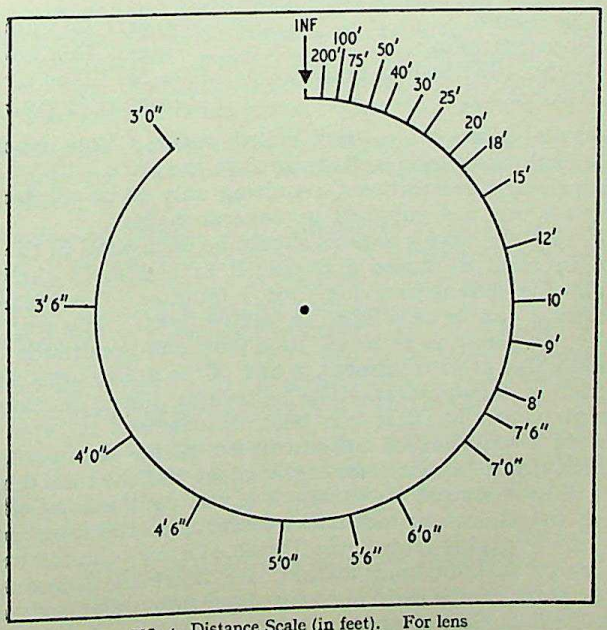

FIG. 4. Distance Scale (in feet). For lens of any focal length.

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Desensitising and Desensitisers

Safranine 1 part in 2,000 parts of water is a reliable desensitiser, but tends to stain the film unduly. The following bath, however, desensitises without stain :—

A.	Phenosafranine (water soluble)	20 gr.	(1 gm.)
	Water	8 oz.	(200 c.c.)
B.	Formalin (37 per cent.) . .	1 oz.	(28 gm.)
	Sodium sulphate (anhydr.) .	1 oz.	(110 gm.)
	Water to make . . .	9 oz.	(1000 c.c.)

1 part of A is added to 9 parts of B and the plates or films are bathed in the mixture for 2 minutes. They are then rinsed and are ready for development. The solution keeps well and hardens the film in hot weather.

Pinacryptol green and pinacryptol yellow are good desensitisers that do not stain. A strength of 1 part of the dye to 5000 parts of water is recommended. A stronger stock solution can be made up and diluted as required. The solution keeps well and may be used many times.

Another non-staining formula is :—

Chrysoidin	9 gr.	(0·5 gm.)
Phenosafranin	9 gr.	(0·5 gm.)
Water (distilled or boiled) . .	4 oz.	(100 c.c.)
Alcohol	40 min.	(2 gm.)

For use, dilute 1 : 50 with boiled water. Both stock and diluted solutions keep well if stored in the dark.

Proprietary desensitisers, requiring only to be diluted with water for use, are supplied by several makers.

The exposed plates or films should be uncovered in the darkroom in total darkness and placed in a dish or tank containing the desensitiser for 1 or 2 minutes. They are then rinsed and can be developed in yellow light. The sensitivity of the emulsion is reduced to about one-hundredth of its normal value after treatment in any of the above desensitisers.

Effect on Development.—The behaviour during development of a plate or film that has been desensitised is often very different from that of an untreated plate. In most cases both the time of appearance of the image and the total development time required to attain a given contrast are altered, and as the alterations are not necessarily in the same proportion, the Watkins factor (see DEVELOPMENT) cannot be used as a guide without modification. As, however, a desensitised film or plate can be developed by inspection, this disadvantage is less serious than it appears at first sight.

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An important point in connection with desensitising is its effect in preventing "aerial fog" due to the oxidation of the developer by contact with air. This is negligible where the plate or film is permanently covered with a thick layer of developer, as in dish or tank development, but is very liable to occur, especially with developers containing hydroquinone, when the partly-developed negative is exposed to the air. For the "see-saw" development of films, or where a developing drum (*q.v.*) is used, desensitising is therefore particularly advisable.

For the theory of desensitising, refer to Chap. 11 of *The Theory of the Photographic Process*, by C. E. K. Mees. (Macmillan.)

Detective Cameras. An early name for HAND CAMERA (*q.v.*).

Developer. Solution for development (*q.v.*).

Developer Improver. Several proprietary products, intended to be added in small amounts to a normal developer, fall under this general description. They appear to be organic anti-foggants, and their chief application is in developers for printing papers. Their effect is to check fog, improve image-colour and allow a greater degree of over-exposure without loss of print quality. Their assistance is of especial value when working with stale paper. (See MEALINESS.)

Developing Agent. The active reducing agent—as metol, hydroquinone, etc.—which is the fundamental constituent of a developer (*q.v.*).

Developing Drum. A cylinder of metal, wood, or glass on the outside of which the film to be developed is wound, face outwards. The drum is supported over a dish or trough of developer at such a height that the film is drawn through the developer as the drum is rotated. To avoid aerial fog, films to be developed in this way should previously be desensitised (see DESENSITISING AND DESENSITISERS). See also DEVELOPMENT, where a developing drum is illustrated.

Development. (See also RAPID PROCESSING and FINE-GRAIN DEVELOPMENT.) Development is the production of a visible image from the invisible or latent image formed on sensitive material by exposure to light.

Function and Composition of Developers.

The emulsion on a film, plate, or bromide or gaslight paper consists of silver halide supported in gelatine. By the action

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of certain chemicals, all of which are reducing agents (absorbers of oxygen, halogens, and related elements) the silver halide can be reduced to metallic silver by removal of the halogen. This process will take place more readily if the silver compound has been exposed to light. A developer takes advantage of this fact, and is a solution of a reducing agent with other constituents added so as to produce a nicely-balanced mixture which will reduce exposed silver salts to metallic silver while leaving unexposed silver salts unacted upon.

In a normal developer there are four usual ingredients. These are (1) the developing agent proper, which actually carries out the reduction (2) an alkali, often called the "accelerator," added because all normal developing agents act most readily in alkaline solution (3) a preservative, normally sodium sulphite, which checks oxidation of the developing agent by the air, and (4) a restrainer, normally potassium bromide, added where necessary to check fog or to compensate for over-exposure.

The developing agent may be pyrogallol, metol, hydroquinone, amidol, paraphenylene-diamine, glycin, etc., or a mixture of two or more of these. It should be noted that practically all developing agents, though colourless, are converted by oxidation into highly-coloured substances with a strong tendency to stain gelatine, paper, and the fingers.

Of the alkalies the most widely used is probably sodium carbonate, which is commonly replaced by sodium hydroxide if high alkalinity is wanted, or by sodium metaborate (Kodalk) or borax if only low alkalinity is needed. As alternatives, often of value in special cases, ammonia, potassium hydroxide or carbonate, tribasic sodium phosphate, or indeed any substance giving rise to an alkaline reaction when dissolved in water may be used. Many modern formulæ appear to contain no alkali at all; in these, as in an amidol developer, sufficient alkalinity is provided by the sodium sulphite. This substance, originally introduced as a preservative to check oxidation of the developing agent during storage of the developer, and to prevent the stains which may arise through atmospheric oxidation during use, acts as a sufficient alkali in many cases, and is used in high concentration in many fine-grain developers (*q.v.*) as an aid to evenness in the structure of the developed image.

The function of a restrainer, usually potassium bromide, is to check fog, by which is meant the production of metallic silver on parts of the plate that have received no exposure.

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Modern negative emulsions are so free from fog that bromide is no longer regarded as an essential ingredient, especially as a plate to be developed in a restrained developer requires extra exposure. Bromide is retained, however, in most developers used for printing-papers, as it is found that it gives a useful control over the colour and contrast of the image. For chlorobromide and similar papers, prolonged exposure followed by development in a very highly restrained developer is commonly used for the production of warm tones.

It is now common practice to use organic restrainers which reduce fog without affecting film-speed. A 2 per cent. solution of 6-nitro-benziminazol, for example, may be used, in the same quantity, in place of the 10 per cent. solution of potassium bromide generally recommended, and additions up to 1 minim per oz. of developer (1 part in 500) will cause no drop in speed while being as effective as bromide in reducing fog. "Developer-improvers" (*q.v.*), are apparently substances of this general type.

The Development of Negatives.

The subject of the development of prints of various types is discussed under headings referring to the individual processes in question (e.g., Bromide Paper, Lantern Slides, etc.) and the development of negative images by obsolete processes will likewise be found under the appropriate heading (e.g., Wet Collodion Process, etc.). All that follows refers to the development of negatives, on glass or celluloid, by the gelatino-bromide process which is the only one in current use today.

Since a plate or film, normally treated, retains its sensitivity to light until it is fixed, development must in all such cases take place either in total darkness or in a light to which the plate is insensitive. Alternatively, the plate may be desensitised (see Desensitising and Desensitisers) after which development may take place in a yellow light bright enough for the process to be readily followed and controlled.

The control of the process of development is an extremely important matter to the photographer, as the extent to which development is continued, in conjunction, of course, with the contrast of the subject, determines the contrast of the finished negative. This point is discussed from the theoretical standpoint under the head of Sensitometry; we shall here be concerned with the practical means used to ensure that the contrast obtained is that which the photographer desires.

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Development by Inspection.

Until comparatively recent years most workers, whether amateur or professional, developed their plates or rolls of film individually "by inspection." This means that development is continued until the photographer, looking through the negative held up to the dark-room lamp, considers that the contrast is sufficiently high, at which stage he terminates development by transferring the negative to the fixing bath.

In the hands of an expert this method was completely satisfactory, but the inexperienced were very liable to make serious mistakes. The most usual cause of these is the natural tendency to judge the degree of development by the density of the image instead of by its contrast, which leads to the over-development of a plate that has received a minimum exposure and the under-development of one that has been more generously exposed. It is to this tendency that we must attribute the erroneous belief, once widely held, that under-exposure increases contrast.

After development is complete the plate is rinsed in clean water and transferred to the fixing bath (*q.v.*). Care should be taken not to expose the film or plate more than is necessary even to the dark-room light, especially before and during the first part of the development. It is a good plan to cover over the developing dish or otherwise shield it from the light.

The high speed and high-colour-sensitivity of modern emulsions do not permit the dark-room to be sufficiently well-illuminated to make development by inspection a very practical procedure; except for special purposes (*e.g.*, developing copy negatives on slow plates) development by time is now almost universal, especially in amateur practice.

Development by Time.

If development is not carried out by inspection, some method of timing development must be used. Where plate or cut film negatives are developed singly, the time may be adjusted to suit the contrast of the subject in an attempt to keep all the negatives made to a constant contrast, but in developing rolls of film all that can be done is to develop to a standard gamma. In this case varying subject-contrasts have to be compensated for by suitable choice of printing paper. Reference to the article on Sensitometry will make it clear that so long as the exposure given lies within the (usually wide) range of correct exposures, all the negatives on

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the film, irrespective of the exposure they may have received, will develop to the same gamma in the same time.

What this time should be, even when the gamma-value desired is settled, depends not only upon the developer used but also upon the characteristics of the emulsion and the temperature at which development is being carried out. By using always the same developer and sticking to one brand of plate or film, all variables except temperature can theoretically be excluded, and it becomes possible to compile a table giving a suitable development time for each temperature. " Time and Temperature " tables on this model are issued by most of the makers of proprietary developers, plates and films being divided up into groups according to their rate of development, and a separate table being provided for each group. Similar information in connection with two or three recommended developers is often also issued by the makers of plates and films.

It must be borne in mind, however, that some slight variation may exist between successive batches of plates or films issued under the same name. Such variations as these supply the reason for the recommendation sometimes made to buy film in periodical large purchases, each of the same batch-number throughout.

Tank Development.

It is this method of development by " time and temperature " that is most commonly adopted today. The reasons for this are manifold, and include the wide use of panchromatic material, which has to be developed in complete darkness unless desensitised, and the almost universal preference for roll film, which means that anything from eight to thirty-six or more negatives are developed at once. Further, the modern miniature negatives are so small as to make judgment of contrast by inspection extremely difficult, while even those who possess fully-equipped dark-rooms now use a tank, not so much for the much-advertised ability to develop in daylight, but mainly because a tank provides the only convenient way of handling a long length of film and keeping it safe from scratches and other mechanical damage.

The most popular type of tank takes the form of a short wide cylinder into which fits a reel upon which the film is wound. In most cases successive turns of film are kept apart by spiral grooves cut in the inner sides of the flanges of the reel. These grooves necessarily emerge at one point on the periphery of the reel ; the film is put into place on the reel by

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simply feeding it into the groove at this point. In an alternative type of tank the film is wound on to a plain ungrooved reel in company with a celluloid "apron." Small projections along both sides of the extreme edge of this serve to hold the film clear of the apron, and to allow the developer full access

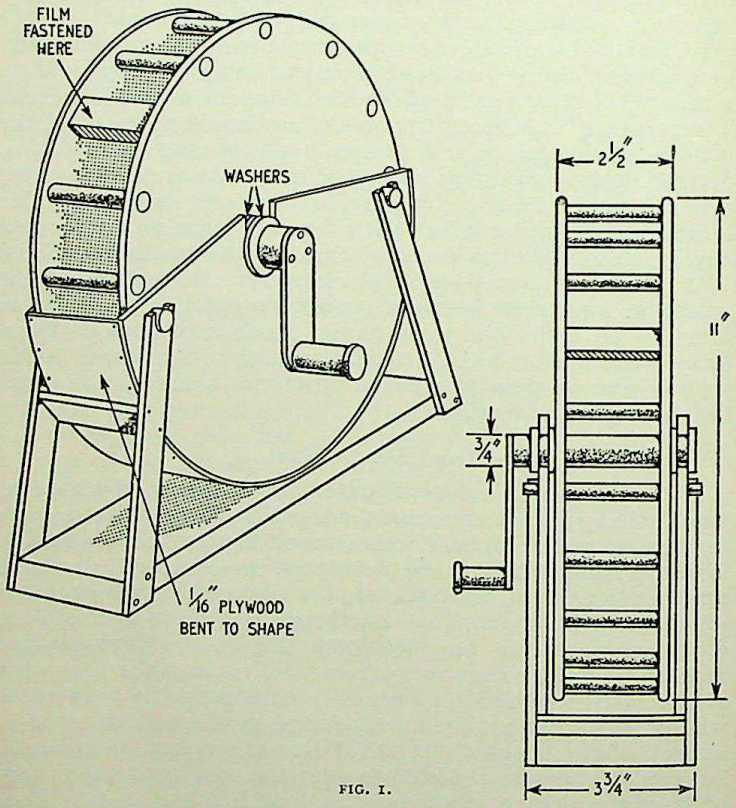

FIG. 1.

to the film, but they do not encroach upon the picture space. Some tanks include mechanism for winding the film upon the spool in daylight without exposing it to light, but the "dark-room loading" tank, in which the film is put into place, normally in total darkness, by the fingers of the operator is very widely used.

Once the film is on the reel, the latter is put into the tank

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and the lid dropped into place. The tank is now light-tight, and all further operations can be conducted by daylight or full artificial light. The tank is filled with developer at a known temperature, and this is allowed to act on the film for the prescribed time. Uneven development is prevented by turning the reel at intervals; usually there is provided a rod which can be dropped through the hole in the centre of the lid to engage with a cross-bar in the central tube of the reel; this enables the latter to be turned without opening the tank. At the expiration of the allotted time the developer is poured off and replaced by a hardening stop-bath (*q.v.*). This is next replaced by hypo, and when the film is fixed this in turn is poured off and the film is washed by simply placing the tank under a running tap for half an hour or so. The construction of the tank is usually such that the water passes through the hollow spindle of the reel and wells up past the film from below, finally overflowing at the top.

It should be noted that many materials, particularly certain metals, will either be attacked and corroded by the developing or fixing solutions, or will go into solution sufficiently to upset their working. Modern tanks for amateur work are made of moulded material, such as bakelite, which is quite inert. The sulphur present in ebonite is a possible source of danger, so that this material is best avoided. Metals, except stainless steel, nickel, lead or type-metal, are inadmissible for various reasons, and copper, tin, bronze, brass, and ordinary solder will all give rise to chemical fog and must be scrupulously avoided. Brass or copper, if heavily nickel-plated, can of course be used, as can any metal if kept out of contact with the solutions by a suitable coating of enamel or cellulose paint. For large tanks, as used for commercial purposes, wooden tanks lined with sheet lead and having welded (not soldered) joints are eminently suitable.

Although the construction of a satisfactory tank is beyond the ability of most amateurs, the simpler developing-drum, for use in the dark-room, is not difficult to make. From the point of view of those who only have occasional films to develop, it has the special advantage of requiring only a minimum of solution. While a drum of glass or stainless metal is to be preferred, one made of wood, well covered with a chemical-resisting cellulose paint, is easier to build, and will serve well for occasional use. The sketch on the preceding page gives all necessary details for the construction of a simple drum for 3¼ × 2¼ films.

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Development in Practice

All that can be done in development is to control the contrast of the finished negative, contrast, of course, being greater with longer development. If it is found that a plate or a roll of film developed according to the tables available has too much or too little contrast to suit the printing process or enlarger to be used, then the time should be reduced or increased suitably in future. No one time is " correct " for development in the sense that all other times are wrong ; published tables of times are at best a guide to be used as a basis for experiment to obtain the type of negative that each individual worker prefers.

It should not be forgotten that the time published will give negatives of average contrast only when the subject itself was of average contrast ; more or less contrast in the subject will be faithfully reflected in the negatives. For contrasty subjects, and particularly portraits or subjects taken by artificial light, it is usually desirable to reduce by one-third times found correct for landscape or snapshot work. Similarly extra time, up to one and a half times the normal, should be given for subjects lacking in contrast.

The Influence of Temperature.

Development, like all other chemical reactions, progresses more slowly at low temperatures than high, and for this reason the temperature of the developer has to be taken into account in fixing development time.

The compilation of a set of times that shall give equivalent results at different temperatures is possible if the temperature-coefficient of the developing solution used is known. The temperature-coefficient is a number by which the time of development at any given temperature must be multiplied or divided to find the time required for equal development at a temperature ten Centigrade degrees (equals 18 Fahrenheit degrees) lower or higher.

It used to be thought that the temperature coefficient of a developing solution is solely dependent upon the developing agent in use, and tables of temperature coefficients, showing very different values for different developing agents, have been published. More recently it has been shown that the emulsion used and the temperature-range considered also play their part, and the same developing solution may have widely different temperature coefficients according to circumstances.

In view of these complexities, it is evidently impossible to construct an *accurate* table showing equivalent development

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times at different temperatures, except by direct experiment with the individual developer formula, and the individual emulsion, with which the table is to be used. Such figures are frequently issued by the makers of plates or films, who are in a position to give accurate values for their emulsion and the developer they recommend; when time-and-temperature tables are issued in connection with a developer, without consideration of individual emulsions, they should be accepted as an approximate guide only, for two emulsions requiring the same development time at, say, 70° F., may require quite different times at 55° F. For this such tables do not usually allow. Nevertheless it is useful to note that most "old-type" developers have a temperature coefficient in the neighbourhood of 1·9, while the modern high-sulphite developer tends to have a coefficient of about 2·2 to 2·5.

The Influence of Dilution.

As a rough rule, the energy of a developer varies with its dilution; that is, if a developer is diluted with its own bulk of water it takes twice as long to do its work. But Dr. Mees has pointed out that there is a big variation from this rule with some developers, as metol and hydroquinone, and also when there is air dissolved in the water. In these cases the time is longer than proportionate to the dilution. With glycin and pyro-soda time seems proportionate to dilution.

It should be noted that when the developer is rich in sulphite, as are most fine-grain developers, the rule that time is proportional to dilution breaks down very badly. It is on record that one fine-grain developer requires to be diluted with nearly five times its own bulk of water to halve the rate (or double the time) of development.

Factorial Development.

It was pointed out by Alfred Watkins in 1893 that the time elapsing between pouring on the developer and the first appearance of the image gives an accurate indication of the activity of the developer. Any variation of temperature, of dilution, or of composition which increases or decreases the time necessary for development to a certain gamma also increases or decreases, in the same proportion, the time of appearance. The same is true of changing from one plate or film to another which develops at a different rate.

The Watkins plan of factorial development is therefore to develop the plate for a fixed multiple of the time of appearance,

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so obtaining always a standard degree of development (gamma). The number by which the time of appearance has to be multiplied to obtain the total time of development is called the "Watkins factor," and varies rather widely for different developing agents.

Some developers, such as hydroquinone, bring up the image slowly, the high lights appearing only after some time, and being so slowly followed by the other tones that by the time all shadow detail has appeared the contrast is already quite high. For such developers the Watkins factor is low—perhaps 4 or 5, according to the contrast desired. Other developers, such as metol or paraminophenol, bring up the first signs of an image very rapidly, with shadow detail following quickly upon the appearance of the lights. If fixed shortly after the shadow detail appears, a metol-developed negative would be exceedingly soft and lacking in contrast; with such developers contrast is only built up slowly, making the Watkins factor as high as 30 or even more. The time of first appearance is in such cases so short that, in spite of the high factor, development is not unduly prolonged. It will be seen that knowledge of the Watkins factor of a developer tells us a great deal about its behaviour; a "short-factor" developer tends to give contrast, and is incapable of giving a soft negative without loss of shadow detail, while a "long-factor" developer such as metol gives detail first, and only provides contrast by continued development.

The factorial method of development has fallen into disuse of late years on account of the high speed and high colour-sensitivity of modern plates and films. Holding the developing dish close against the dark-room lamp while watching for the image to appear will almost inevitably fog a modern emulsion, so that, except for slow plates, factorial development is but little used.

It is, however, interesting to note that the principle of testing the activity of the developer before using it has recently been revived by P. K. Turner, who suggests the use of gaslight paper for the purpose. In this application of the Watkins method the multiplying factor must of course take account of the speed of development of the film as well as of the character of the developer used.

The Watkins factors of the various developing agents, and of individual formulæ, where known, are given with the formulæ later in this article.

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Stand Development.

It was at one time fashionable to use an extremely dilute and slow acting developer (usually glycin), in which plates were left for several hours or even overnight. This method was the forerunner of modern tank development by time, by which it has been completely superseded.

Choosing a Developer.

(For special fine-grain developers for miniature films, see Fine-Grain Development; Solutions and Solubility; and entries under the names of individual developing agents.)

The immense increase in the popularity of the miniature camera, and the growing use of thin-emulsion films, have between them quite considerably changed the outlook on development during the last few years. Not so long ago it was accepted practice to choose a film of fairly high speed, and develop it lightly in a fine-grain developer to ensure that the graininess of the finished negative should not be too high. The "normal" fine-grain developer, regarded as a standard by which all others were judged, was the Kodak D76 or Ilford ID.11 MQ-borax, but there were numerous other developers giving finer grain in exchange for some loss of effective film-speed. Developers of the latter class are now declining in popularity, but MQ-borax remains, for many workers, a standard developer. For those making negatives larger than 24 × 36 mm., this developer, or its approximate equivalent, seems likely to remain a favourite for many years yet, for it gives a high effective film-speed with quite moderate graininess. Its main disadvantage is that it does not preserve the full acutance (*q.v.*) of the film, a point that does not matter much to the user of the larger sizes, but which tends to restrict its usefulness to the miniature or sub-miniature worker. Nevertheless, films have improved so much both in acutance and in fineness of grain in recent years that very many miniaturists are content to continue with the fairly fast film and the MQ-borax developer, for they obtain sharper and less grainy negatives than they could have obtained by the same means a few years ago. In this method of working, it is customary to give exposures that, in fact, are rather more than the minimum correct exposure, so that in practice the full speed of the film is not used. The slogan behind this procedure is still that current in the early days of the Leica—"Expose generously, develop lightly".

Shortly before the Second World War Willi Beutler, in

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Germany, preached a new doctrine. His recommendation was to choose a slow fine-grain film, give it the absolute minimum of exposure (so making it, in practice, but little slower than the faster films given generous exposure) and to develop to low or moderate contrast in a fairly active developer (metol-carbonate with low sulphite content) designed to bring out the full speed of the film but having no pretentions to special fine-grain properties—the film was relied upon for fineness of grain. This procedure soon became popular in Germany, but did not attract much attention in England until the advent of the thin-emulsion film. These films, first publicised in Germany, have a depth of emulsion much less than that found in earlier films, and their emulsion is much denser, that is, there are more crystals of silver bromide per cubic millimetre. The latter means that light reflected by the crystal upon which it first falls has not so far to travel sideways before it encounters another crystal that may absorb it; the former means that light diffused by the top layer of crystals has not so far to travel, and hence cannot spread so much, before it is absorbed by the tinted celluloid base. As is evident, both these properties mean that the picture recorded on the film will be sharper, but they mean, also, that exposure must be quite closely correct, for if exposure is excessive every crystal in the emulsion may be made developable in the highlight regions, with complete loss of highlight gradation. Workers accustomed, as most now are, to reversal colour film, which has even less latitude, do not find the restricted latitude of the thin-emulsion film a serious disadvantage in practice.

The Beutler method of working only came to the fore in England when the film-makers began to publicise their " thin-emulsion " or " high-acutance " films, and the purchasers of the films, who bought them for the sharper negatives they could yield, found that the developer recommended was a Beutler-type formula, either for making up at home or in proprietary form. A further encouragement to this method of working has been provided by the improvement of medium and fast films, many of which now have at least some approximation to the thin dense emulsion originally associated only with quite slow films, and have a fineness of grain that is continually being improved.

As a result of all this, the Beutler system of working is becoming widespread, even among those to whom the name of its originator means nothing, and it has contributed a good deal, by improved sharpness, to the popularity of, and the satisfac-

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tion with, the miniature camera. As a corollary to this, the special fine-grain developers offering finer grain than MQ-borax but necessitating longer exposures are falling out of favour, partly because they are hardly needed nowadays but more because their solvent action on the silver bromide crystals tends to spread the image a trifle and so detract from sharpness.

There is a third class of developer, generally made up on the MQ-borax principle, that uses a special developing agent such as Phenidone and so achieves an increase in effective film speed of 50 per cent or more. These are all proprietary developers, and their composition has not been disclosed, but their purpose and use is evident from what has already been said.

A most interesting survey of modern development by Geoffrey W. Crawley can be found in a series of articles published in the *British Journal of Photography* for December 2, 9, 16, 23, and 30, 1960, January 6, 13, and 27, 1961, in which development formulae for various purposes (high speed, fine grain, high acutance) are discussed in conjunction with films of different makes and speeds. Since none of the formulae is unreservedly recommended for all films, and since further the properties of films may change during the currency of this book, formulae are not quoted here.

Few modern amateurs make up their own developers from bulk chemicals; most buy a ready prepared developer in tin, packet or bottle. The table below includes a selection of proprietary film developers and divides them into the three classes mentioned—but as the formulae are mostly not published, it is not possible to guarantee that every developer is correctly classified.

High Acutance	*MQ-borax*	*Speed-increasing*
Kodak H. D.	D.76	Promicrol
Neofin blue	ID.11	Microphen
Adox E.10	M&B 320	Adox E.24
Definol	Unitex	Atomal
Granofin		Ultrafin
Rodinal	*Fine-grain:*	
Azol	*Speed reducing*	
Kodinal	Microdol	
	ID.48	
	Unitol	

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Development: Film Speed

Development and Film Speed.

Of late years a great deal of interest has been taken in " development to finality " as a means of increasing effective film speed. There is nothing new about this technique, which, under the perhaps more expressive name of " forced development," has been used to combat under-exposure since the earliest days of dry plates—and perhaps in the wet-plate era too. The reduction of exposure below the normal that can be compensated for by forced development cannot be stated with precision, because it depends to a small extent on the developer chosen, to a considerable extent on the emulsion in use, and also, again quite considerably, on the contrast of the subject being photographed.

The principle involved is simple. If a film with a long toe to its characteristic curve (see SENSITOMETRY) is given an exposure such that all tones of the subject lie on the toe, and is then developed normally, the result will be a very thin negative of low contrast, with the detail in the deepest shadows too faint to be visible to the eye, though microscopic examination would demonstrate the presence of a small number of silver grains. This is, of course, a description of a badly underexposed negative. As development is prolonged, both density and contrast increase, so that the slope of the toe increases until it is about that of the straight-line part of a negative normally exposed and developed; fog sets a limit to the increase in development that can usefully be employed. If the toe of the curve is too short, or the contrast of the subject too high, the brighter tones will fall on the straight-line part of the curve; their contrast and density will then be excessive when development is forced, giving a negative with blocked-up highlights.

The increase in speed claimed for this procedure is generally indicated by stating at what film-speed the emulsion can be rated in determining exposure. This is misleading as an indication of speed-increase, for all exposure meters are scaled so as to have a factor of safety—often they indicate four times the absolute minimum of exposure which, with normal development, would give a satisfactory negative of a subject of moderate contrast. Possibly the absolute increase in speed possible is of the order of three times, though as mentioned it must depend considerably on the emulsion in use.

Developers specially devised for this method of working have been placed on the market commercially, and though

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comparison shows that they are not appreciably more effective in increasing film speed than is a standard M.Q.-borax developer, they are normally accompanied by detailed instructions showing the development time required to compensate, with many different films, for any one of several known degrees of underexposure. This information will save the intending user many hours of tedious experimental work. At the same time the need to relate development time closely to the degree of under-exposure, an essential when working on the toe of the film's curve, makes the procedure of forced development quite unsuitable for general photography, however invaluable it may be in difficult circumstances.

Some Standard Formulæ.

D.76 : I.D.11—For all everyday work, the following M.Q.-borax formula, as recommended by two leading manufacturers, will prove entirely satisfactory, especially for negatives of larger than miniature size, and with most high-speed miniature films.

Metol	17½ gr.	(2 gm.)
Sodium sulphite (anhyd.) .	880 gr.	(100 gm.)
Hydroquinone . . .	44 gr.	(5 gm.)
Borax	17½ gr.	(2 gm.)
Water to	20 oz.	(1000 c.c.)

Keeping Properties.—It has been found that on standing the activity tends to rise. On these grounds formula D.76d is preferable. Keeps well in other respects if properly stored.

Watkins Factor.—Factor 8·0 for gamma of 0·7.

Development Time.—With continuous agitation, about 8 to 12 minutes at 65° F., with the fastest films.

Exhaustion.—After about 100 sq. in. (650 sq. cm.) of exposed film have been developed in half a litre (17½ oz.), the development time must be increased by 25 per cent., and emulsion-speed is reduced to 65 per cent. of its original value.

The above-mentioned amount corresponds approximately to two 36-exposure strips of 35-mm. film, three 8-exposure V.P. films, one and a half 8-exposure 3¼ × 2¼ films, or about 7 quarter-plates.

Replenisher for D.76

By adding a small amount of the following replenisher to a tank of D.76 in frequent use, development times may be kept unchanged during the development of many films.

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D.76R	Metol	26 gr.	(3 gm.)
	Sod. sulphite (anhydr.)	2 oz.	(100 gm.)
	Hydroquinone	66 gr.	(7·5 gm.)
	Borax	175 gr.	(20 gm.)
	Water to	20 oz.	(1000 c.c.)

Add sufficient D.76.R to keep the level of the liquid in the tank constant. Not more than 1 part D.76.R should be added to 4 parts D.76.

D.76d.—If D.76 or I.D.11 is to be kept some time before use, the rise in activity on standing may be objectionable as leading to uncertainty in development time. To avoid this the quantity of borax may be raised to 70 gr. (8 gm.) and an equal amount of boric acid added. This gives formula D.76d, which can be kept before use for long periods without change in activity. In all other respects its properties are identical with those of D.76 or I.D.11.

Ilford I.D.68.—The following formula uses phenidone in place of metol, but is otherwise similar to I.D.11. It keeps better, is less liable to stain, and will not produce dermatitis in those susceptible to metol poisoning.

Sod. sulphite (anhydr.)	2 oz.	(100 gm.)
Hydroquinone	44 gr.	(5 gm.)
Borax	17½ gr.	(2 gm.)
Boric acid	8 gr.	(1 gm.)
Potass. bromide	8 gr.	(1 gm.)
Phenidone	1½ gr.	(0·2 gm.)
Water to	20 oz.	(1000 c.c.)

20 oz. will develop at least 200 sq. in. of film; development times are 30 to 60 seconds longer than for I.D.11.

Edwal 10.—Similar to D.76 and I.D.11, but uses glycin in place of hydroquinone, as a result of which better gradations, especially in the middle tones, are claimed.

Metol	44 gr.	(5 gm.)
Sodium sulphite (anhydr.)	880 gr.	(100 gm.)
Glycin	44 gr.	(5 gm.)
Borax	88 gr.	(10 gm.)
Water to	20 oz.	(1000 c.c.)

Development Times and other characteristics: As D 76.

Agfa 14.—This is a developer similar to D.76 and I.D.11 except that it uses no hydroquinone, while the low alkalinity is provided by using a small amount of carbonate instead of by using borax.

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The formula is :—

Metol	40 gr.	(4·5 gm.)
Sodium sulphite (anhyd.)	750 gr.	(85 gm.)
Sodium carbonate (anhyd.)	9 gr.	(1 gm.)
Potassium bromide . .	4½ gr.	(0·5 gm.)
Water to	20 oz.	(1000 c.c.)

Development Time.—Twelve minutes at 65° F. with the fastest Agfa films.

Exhaustion.—No precise data are available, but after considerable use it can be regenerated by adding a further 6 gr. (0·7 gm.) of sodium carbonate.

Film Speed.—The presence of bromide may cause a small loss in film speed.

Beutler High-Acutance Developer.—This is not a fine-grain developer, but is recommended as giving maximum sharpness on thin-emulsion films of slow or moderate speed. Exposures should be the necessary minimum, but not more.

A.	Metol	90 gr.	(10 gm.)
	Sod. sulphite (anhydr.) .	1 oz.	(50 gm.)
	Water to . . .	20 oz.	(1000 c.c.)
B.	Sod. carbonate (anhydr.) .	1 oz.	(50 gm.)
	Water to . . .	20 oz.	(1000 c.c.)

For use, add 1 part A and 1 part B to 10 parts of water. Use once and discard. Development time, 6 to 9 minutes at 68° F.

Paraminophenol Hot-Weather Developer.—May safely be used for development at temperatures up to 90° F., giving fine grain and well-graded negatives. Has very little tendency to soften the emulsion.

Paraminophenol (base) . .	30 gr.	(3·5 gm.)
Sodium sulphite (anhydr.) .	800 gr.	(90 gm.)
Sodium sulphate (cryst.) . .	800 gr.	(90 gm.)
Water to	20 oz.	(1000 c.c.)

Keeping Properties.—Good, but the base may crystallize out at temperatures much below 70°.

Development Times.—For fastest films, up to 15 minutes at 70° F. Corresponding time at 75°, 12½ minutes; at 80°, 10½ minutes; at 85°, 9 minutes; at 90°, 7½ minutes. When developing at a high temperature, the film must be transferred direct, *without rinsing*, to a hardening stop-bath or hardening fixer at the same temperature as the developer.

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Below 75° F., the sulphate may be omitted; development time up to 15 minutes at 65° for the fastest films.

Exhaustion.—Each half-litre (17½ oz.) will develop four 36-exposure strips of 35-mm. film. Increase development time by 10 per cent. for each film after the first.

Emulsion Speed.—No speed is lost.

Grain.—Very fine at 65° or 70° F., but less so at higher temperatures.

NON-FINE-GRAIN DEVELOPERS STILL IN CURRENT USE

Before 1914, there were available a number of developing agents which have not reappeared since that date. Formulæ for these are given for reference, but to avoid confusion they are placed in a separate section headed "Historical and Traditional Developers." In the same section are placed other formulæ, such as for pyro-ammonia and ferrous oxalate developers, that have had importance in the past but are no longer in current use.

Arrangement is chiefly alphabetical by name of developing agent; where a single formula contains more than one developing agent, it is placed under the name of that usually first mentioned in speaking of the mixture. Thus metol-hydroquinone will be found under *Metol*, but pyro-metol will be found under *Pyrogallol*.

Adurol.—Pre-1914 trade name for Chlorquinol (*q.v.*).

Amidol.—Synonym, diaminophenol. Watkins factor 18. This developer is more frequently used for papers than for negatives. The following formula is reliable for negative work:—

Amidol	20–30 gr. (4·5–7 gm.)
Sodium sulphite (cryst.) .	250 gr. (57·5 gm.)
Potassium bromide . .	6 gr. (1·5 gm.)
Water to	10 oz. (1000 c.c.)

This developer will keep at most a day or so, and to work at its best should be freshly made up with dry chemicals.

Acid Amidol.—See under LANTERN SLIDES. See also AMIDOL.

Azol.—Watkins factor 30. A commercial concentrated one-solution developer, usually stated to be based on paramino-phenol (*q.v.*).

Certinal.—Watkins factor 30. A commercial concentrated one-solution developer, usually stated to be based on paramino-phenol (*q.v.*).

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Chlorquinol.—Synonyms, Adurol, Chlor-hydroquinone. Watkins factor 5. This is a clean-working developer somewhat akin to hydroquinone, but develops more quickly and is said to be less affected by temperature. It is also more soluble and keeps better. The following concentrated one-solution formula can be recommended :—

Sodium sulphite (cryst.) . .	4 oz.	(400 gm.)
Potassium carbonate . .	3 oz.	(300 gm.)
Water	10 oz.	(1000 c.c.)
Chlorquinol	½ oz.	(50 gm.)

For use take 1 part with 4 parts of water.

Chlorquinol developer can be made up in two solutions as follows :—

A.	Chlorquinol . . .	220 gr.	(25 gm.)
	Sodium sulphite (cryst.) .	4 oz.	(200 gm.)
	Water to	30 oz.	(1500 c.c.)
B.	Sodium carbonate (cryst.) .	6½ oz.	(325 gm.)
	Potassium bromide . .	22 gr.	(2·5 gm.)
	Water to	20 oz.	(1000 c.c.)

For use, take 3 parts A to 2 parts B. Development time for average films at 65° F., 5 to 7 minutes.

See also *Metol-Chlorquinol* (below).

Glycin.—Watkins factor 8 to 12. A clean-working, slow-acting developer at one time much used for stand and tank development. Figures in many modern fine-grain formulæ (see FINE-GRAIN DEVELOPMENT), and in warm-tone developers for chloro-bromide papers.

For negative development the following is recommended by Johnsons of Hendon Ltd.:—

Sodium sulphite (cryst.) . .	220 gr.	(25 gm.)
Potassium carbonate . .	440 gr.	(50 gm.)
Glycin	80 gr.	(9 gm.)
Potassium bromide . . .	5 gr.	(0·5 gm.)
Water to	20 oz.	(1000 c.c.)

For the fastest films, develop for 12 minutes at 65° F., other films, about 8 minutes. If the solution is diluted for tank work, extend the time proportionally to the dilution. About 2½ oz. (70 c.c.) of undiluted developer is sufficient to develop an 8-exposure 3¼ x 2¼ spool.

Hydroquinone.—Watkins factor 3 to 5. A slow-acting developer, inclined to give fog unless bromide is included,

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when it gives very clean negatives. Generally used in conjunction with *metol*, except for process work, for which a hydroquinone-caustic soda formula is generally recommended as giving maximum contrast. It is included, in large proportion, in nearly all developers for papers, as it helps to provide rich blacks and sparkling contrast. See also *Controlling Gradation* under BROMIDE PAPER.

The low Watkins factor of hydroquinone implies that shadow detail only appears towards the end of development, with the result that when developing to low or moderate contrast much shadow detail is lost unless the exposure has been considerably in excess of normal. For that reason hydroquinone is no longer used alone except where maximum contrast is required, as in line copying.

Maximum Contrast Developer for Line Work.

A.	Potassium metabisulphite	110 gr.	(25 gm.)
	Hydroquinone	110 gr.	(25 gm.)
	Potassium bromide	110 gr.	(25 gm.)
	Water to	10 oz.	(1000 c.c.)
B.	Caustic soda	200 gr.	(45 gm.)
	Water to	10 oz.	(1000 c.c.)

For use, take equal parts of A and B.

Meritol.—A developing agent, stated to be an addition-compound of paraphenylene-diamine and pyrocatechin, used in FINE-GRAIN DEVELOPMENT (*q.v.*).

Metol.—Watkins factor 30. A developer of high energy capable of giving low contrast negatives without loss of detail. Generally used in conjunction with hydroquinone, and frequently introduced into fine-grain developers intended to permit minimum exposure. (See FINE-GRAIN DEVELOPMENT.) Combined with pyrogallol (*q.v.*) to give pyro-metol, makes one of the most quick-acting and energetic developers known.

Metol or Phenidone is an ingredient in practically every modern developer, both for negatives and prints, except those intended to give warm tones on prints or slides.

Metol has a tendency to attack the skin of some people and cause unpleasant sores. (See SKIN, EFFECTS OF CHEMICALS ON.)

The following is a well-known metol formula (Ilford I.D.3) giving soft gradation and maximum shadow detail:—

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Metol	52 gr.	(6 gm.)
Sodium sulphite (anhydr.) .	½ oz.	(25 gm.)
Sodium carbonate (anhydr.) .	¾ oz.	(37·5 gm.)
Potass. bromide . . .	9 gr.	(1 gm.)
Water to	20 oz.	(1000 c.c.)

For use, dilute one part of the above with 3 parts water. Average developing time, 12 to 15 minutes at 68° F.

Metol-Chlorquinol.—This mixture, though more expensive than M.Q., has the advantage that the chlorquinol, unlike hydroquinone, remains active at comparatively low temperatures. Further, there is less tendency to aerial fog, so that it is to be preferred for film development on a drum or by the see-saw method. Any of the M.Q. developers above can be converted to metol-chlorquinol by replacing each four grains or grams of hydroquinone by five grains or grams of chlorquinol.

Metol-Hydroquinone—This combination is probably the most popular of all developers today, as it can be used equally well for plates, films and papers. It is generally known as "M Q.", in which the "Q" stands for quinol, a synonym for hydroquinone. The following is the Ilford ID 2 formula for negatives.

Metol	20 gr.	(2 gm.)
Sodium sulphite (cryst.) .	3 oz.	(150 gm.)
Hydroquinone . . .	80 gr.	(8 gm.)
Sodium carbonate (cryst.) .	2 oz.	(100 gm.)
Potassium bromide . .	20 gr.	(2 gm.)
Water to	20 oz.	(1000 c.c.)

For use, dilute 1 part of above with 2 parts of water. The average roll film should be developed for about 5 minutes at 65° F. Corresponding times for 55° and 75° F. are 7½ and 3½ minutes respectively. For tank development, dilute one part of stock solution with 5 parts of water, and develop for 6 to 12 minutes at 68° F.

Universal Developer. The following formula, designed for gaslight paper (*q.v.*), can equally well be used for bromide and chloro-bromide paper, and for plates or films. It keeps well in air-tight bottles.

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Development: Older Formulae

Metol	14 gr.	(1.5 gm.)
Sodium sulphite (anhydr.)	220 gr.	(25 gm.)
Hydroquinone	56 gr.	(6·5 gm.)
Sodium carbonate (anhydr.)	300 gr.	(35 gm.)
Potassium bromide	4 gr.	(0·4 gm.)
Water to	20 oz.	(1000 c.c.)

For gaslight papers, use undiluted. For bromide paper mix with equal bulk of water, and add 1 to 3 drops of 10 per cent. bromide to each ounce. For dish development of negatives, dilute with equal bulk of water, and develop average roll film for 3½ min. at 65° F. For tank development, mix 1 part with 3 parts of water, and develop average roll film for 7 min. at 65° F.

If desired, a stock solution may be made up at double the strength shown in the formula.

Maximum Energy Developer. The following will produce the maximum of shadow detail on an under-exposed plate or film. (Kodak D. 82 formula.)

Water (about 125° F.)	15 oz.	(750 c.c.)
Wood alcohol	1 oz.	(48 c.c.)
Metol	120 gr.	(14 gm.)
Sodium sulphite (anhydr.)	460 gr.	(52·5 gm.)
Hydroquinone	120 gr.	(14 gm.)
Sodium hydroxide	75 gr.	(8·8 gm.)
Potassium bromide	75 gr.	(8·8 gm.)
Water to	20 oz.	(1000 c.c.)

Development time, 4 to 5 minutes at 65° F.

Paraminophenol.—Watkins factor 16 to 30. An energetic non-staining developer, giving an absolute minimum of fog. It particularly lends itself to the preparation of a concentrated one-solution developer, and is the basis of most commercial developers of this type (e.g., Azol, Certinal, Rodinal).

Boil about 20 oz. (550 c.c.) of water briskly for a few minutes, and allow to cool. In 5 oz. (150 c.c.) of it, dissolve 1 oz. (30 gm.) of anhydrous sodium sulphite, or double that weight of crystals, and stir in 1 oz. (28½ gm., or 1 oz. as bought) of paraminophenol to form a cream. Then pour in 175 gr. (11·35 gm.) of pure caustic soda dissolved in about 1 oz. (30 c.c.) of water. This will dissolve the paraminophenol completely. Then add cautiously, a drop or two at a time, a

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concentrated solution of potassium metabisulphite or, if more convenient, concentrated hydrochloric or glacial acetic acid diluted with an equal bulk of water. Only a drachm or so (some 5 c.c. at most) will be needed. Stir vigorously after each addition. A white precipitate of paraminophenol will appear each time; at first this will instantly redissolve on stirring. Continue till the precipitate refuses to dissolve; then make up to a total bulk of 11½ oz. (325 c.c.) with cold water, stir, and bottle immediately in a number of small bottles, each filled right up and tightly closed with a rubber cork.

Note particularly that if paraminophenol hydrochloride is used, it will not all dissolve; plain paraminophenol (the base) must be used.

For dish development of negatives, dilute 1 part with 24 of water, and develop average roll films for 9–10 min. at 65° F. Or may be used at double the strength for half the time. For tank development, dilute 1 part with 40 or 60 of water, and develop an average roll film for 15 or 24 minutes at 65° F. Watkins' factor 30 for average negatives.

With bromide paper, dilute as for dish development, and add a little bromide or developer-improver. Gives very soft prints. (See *Controlling Gradation* under BROMIDE PAPER.) For *gaslight* paper, take 1 part to 15 parts of water, and add a few drops of 10 per cent. bromide to each ounce.

Paraphenylene diamine.—A developing agent used in FINE-GRAIN DEVELOPMENT (*q.v.*).

Phenidone - Hydroquinone.—Particularly recommended for those who suffer from metol poisoning. In most other respects closely resembles metol-hydroquinone (I.D.2. formula), but has longer life and very much less tendency to stain either the fingers or clothing.

Ilford ID. 67.

Sod. sulphite (anhydr.)	1½ oz.	(75 gm.)
Hydroquinone	70 gr.	(8 gm.)
Sod. carbonate (anhydr.)	¾ oz.	(37·5 gm.)
Phenidone	2·2 gr.	(0·25 gm.)
Potass. bromide	17½ gr.	(2 gm.)
Benzotriazole	1·3 gr.	(0·15 gm.)
Water to	20 oz.	(1000 c.c.)

For dish use, add 1 part to 2 parts water. Development times, 2½ to 5 min. at 68° F. For tank use, add 1 part to 5

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parts water. Development times, 5 to 10 min. at 68° F. For convenience, dissolve 10 gm. benzotriazole in 1000 c.c. of 1 per cent. sodium carbonate solution, and add 145 min. (15 c.c.) of this solution in place of the solid. Or use IBT restrainer in the same quantities.

Pyrogallol.—Watkins factor 3¼ to 18, according to formula. This developing agent, familiarly known as "pyro," or sometimes as "pyrogallic acid," was one of the earliest suggested for dry plates. For many years it was almost universally used for the development of plates by inspection, but has now been almost entirely superseded by other more modern developers. Unless much sulphite is used, the image is reinforced by a yellow stain, which makes the negative print as though it were more contrasty than examination by eye would suggest. It is probably this stain that lies at the basis of the claim, sometimes made by older workers, that no other developer can give negatives of the true "pyro quality."

Numberless formulæ have been suggested for pyro developers, and every possible alkali has been used in conjunction with it. The pyro-soda developer, which uses sodium carbonate, is the chief survivor of these. The Ilford formula is an old-established favourite and is given below. Watkins factor, 4½.

Ilford Pyro-Soda.

Stock Pyro (10 per cent.).

Potassium metabisulphite	110 gr.	(6 gm.)
Pyro	1 oz.	(25 gm.)
Water to	10 oz.	(250 c.c.)

This solution will keep for prolonged periods without serious oxidation.

A. (1 per cent. Pyro)

Pyro stock solution	2 oz.	(100 c.c.)
Water to	20 oz.	(1000 c.c.)

B.

Sodium sulphite (cryst.)	2 oz.	(100 gm.)
Sodium carbonate (cryst.)	2 oz.	(100 gm.)
Potassium bromide	12 gr.	(1·2 gm.)
Water to	20 oz.	(1000 c.c.)

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For use, take equal parts of A and B. Time of development for average roll films, 7½ minutes at 55° F., 5 minutes at 65° F., 3½ minutes at 75° F. Where possible, development should take place at 65° F. or thereabouts.

Another well-known pyro-soda formula is the non-staining developer sponsored by the *British Journal of Photography*. This is :—

A. Potassium metabisulphite	160 gr.	(18·3 gm.)
Sodium sulphite	1280 gr.	(148 gm.)
Potassium bromide	40 gr.	(4·6 gm.)
Pyro	160 gr.	(18·3 gm.)
Water to	20 oz.	(1000 c.c.)
B. Sodium carbonate	1280 gr.	(148 gm.)
Water to	20 oz.	(1000 c.c.)

For use, take A, 1 part ; B, 1 part ; water 2 parts. Time of development, 4–8 minutes at 65° F. according to contrast required and type of emulsion in use. Watkins factor, 5.

Pyro-Metol.—This mixture combines the extreme energy and detail-giving power of metol with the density-giving characteristics of pyro. The latter can be enhanced by the yellow colour of the image that results when sulphite is omitted from the formula, and a developer made up on these lines was for long regarded by pressmen as the best possible solution in which to develop an under-exposed plate.

The following is the Kodak D167 formula.

A. Pyro	130 gr.	(15 gm.)
Metol	45 gr.	(5 gm.)
Potassium metabisulphite	88 gr.	(10 gm.)
Water to	20 oz.	(1000 c.c.)
B. Sodium carbonate (cryst.)	4 oz.	(200 gm.)
Water to	20 oz.	(1000 c.c.)

For use, equal parts of A and B. Development time for average roll film, normally exposed, 1¾ minutes at 65° F.

Pyrocatechin—Watkins factor 10. This developer is not in current use in England, but not infrequently appears in German publications. A modern formula is :—

A. Sodium sulphite (anhydr.)	350 gr.	(40 gm.)
Pyrocatechin	175 gr.	(20 gm.)
Water to	20 oz.	(1000 c.c.)
B. Potassium carbonate	1050 gr.	(120 gm.)
Water to	20 oz.	(1000 c.c.)

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In preparing A, dissolve a pinch of sulphite, boil the water for 10 min., then add rest of sulphite and the pyrocatechin.

For use, take 1 part A, 2 parts B, and 1 part water. Develop average films for 4–6 minutes at 65° F.

Compensating Developer. The following, due to Windisch, is a tank developer claimed to prevent halation, to retain high light detail in even the most contrasty subjects, and to compensate for over-exposure. It is recommended for high acutance on thin-emulsion films.

A.	Sodium sulphite (anhydr.) .	110 gr.	(12·5 gm.)
	Pyrocatechin . . .	700 gr.	(80 gm.)
	Water to	20 oz.	(1000 c.c.)
B.	Caustic soda . . .	2 oz.	(100 gm.)
	Water to	20 oz.	(1000 c.c.)

Prepare A as noted in preceding formula.

For normal and contrasty subjects, take 12 parts A, 7 parts B, and 500 parts water, and develop an average film for 15 to 20 min. at 65° F. For extremely contrasty subjects, take 20 parts A, 5 parts B and 500 parts water, and develop for 18 to 20 minutes.

Rodinal. Watkins factor 30. A commercial concentrated one-solution developer based on paraminophenol. (See RODINAL.)

HISTORICAL AND TRADITIONAL DEVELOPERS.

Edinol.—Watkins factor 20. An energetic developer related to metol. It has not been available for many years. A typical formula was :—

Sodium sulphite . . .	5 oz.	(250 gm.)
Edinol	88 gr.	(10 gm.)
Sodium carbonate . . .	$2\frac{3}{4}$ oz.	(135 gm.)
Water	20 oz.	(1000 c.c.)

For use, take 1 part of above and 1 part water.

Eikonogen.—Watkins factor 9. This developer, a naphthol derivative, has not been available since 1914. Typical formulæ were :—

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A.	Sodium sulphite	1 oz.	(100 gm.)
	Eikonogen	¼ oz.	(25 gm.)
	Distilled water	10 oz.	(1000 c.c.)
B.	Potassium carbonate	¾ oz.	(75 gm.)
	Distilled water	10 oz.	(1000 c.c.)

For use, mix equal parts of A and B.

One Solution.

Sodium sulphite	1 oz.	(100 gm.)
Sodium carbonate	½ oz.	(50 gm.)
Distilled water	10 oz.	(1000 c.c.)
Eikonogen	¼ oz.	(25 gm.)

Ferrous Oxalate.—This developer has not been in general use for many years, but was considerably used in the early days of dry plates.

A ferrous oxalate developer for plates and films is made as follows :—

A.	Hot water	10 oz.
	Potassium oxalate (neutral)	2½ oz.
B.	Hot water	10 oz.
	Sulphuric acid	15 min.
	Ferrous sulphate	2½ oz.

Mix 1 oz. of B with 3 to 4 oz. of A (pour B into A, and not *vice versa*).

Ortol.—Disappeared from the British market in 1914. A standard formula was :—

A.	Ortol	70 gr.	(15 gm.)
	Potassium metabisulphite	35 gr.	(8 gm.)
	Water, cold	10 oz.	(1000 c.c.)
B.	Sodium carbonate	1¼ oz.	(125 gm.)
	Sodium sulphite	1¾ oz.	(175 gm.)
	Potassium bromide	5-10 gr.	(1·1-2·3 gm.)
	Water	10 oz.	(1000 c.c.)

The potassium bromide may be left out in cold weather.

For rapid development take 1 part of A and 1 part of B. For slower development and softer results dilute the mixed developer with an equal quantity of water.

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Development: Historical Formulae

Pyro-Acetone.—Make up the following stock solution:—

Pyro	1 oz.	(100 gm.)
Sodium sulphite	4 oz.	(400 gm.)
Boiled water	9 oz.	(900 c.c.)

For normal exposures use :—

Pyro stock solution	40 min.	(10 c.c.)
Acetone	40 min.	(10 c.c.)
Water	1 oz.	(120 c.c.)

Pyro-Ammonia.—In the early dry-plate days this developer was a great favourite, but is now but little used. Owing to the volatile character of the alkali, it is not reliable either for time or factorial development.

A. Pyro	1 oz.	(100 gm.)
Sodium sulphite	2 oz.	(200 gm.)
Citric acid	20 gr.	(4 gm.)
Water to	10 oz.	(1000 c.c.)
B. Ammonia ·880	1 oz.	(100 c.c.)
Water to	10 oz.	(1000 c.c.)
C. Ammonium bromide	1 oz.	(100 c.c.)
Water to	10 oz.	(1000 c.c.)

For use, take A, 10 minims ; B, 10 minims ; C, 5 minims ; water, 1 oz. (2 c.c. each of A & B, 1 c.c. of C. and 100 c.c. of water.)

Pyro-Caustic.—Pyro in conjunction with caustic soda or caustic potash makes a rapid and economical developer. (But see PYROGALLOL). Valenta's formula is as follows :—

A. Pyro	110 gr.	(25 gm.)
Sodium sulphite	1¾ oz.	(162·5 gm.)
Water to	10 oz.	(1000 c.c.)
B. Caustic potash	50 gr.	(11·5 gm.)
or		
Caustic soda	35 gr.	(8 gm.)
Water to	10 oz.	(1000 c.c.)

For use, take A, 1 oz. ; B, 1 oz. ; water, 1 oz.

Pyro-Soda for Plate-Testing.—The Hurter and Driffield standard pyro-soda developer for plate-speed-testing was :—

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Pyro	8 parts
Sodium carbonate	40 parts
Sodium sulphite	40 parts
Water to	1000 parts

A.S.A. and B.S.I. Developer for Speed Testing.—The developer specified by the American Standards Association for measuring the sensitivity of photographic negative emulsions, and expected to be specified also in a Standard due to be published by the British Standards Institution, is as follows:—

Metol	9 gr.	(1 gm.)
Sodium sulphite (anhydr.)	220 gr.	(25 gm.)
Hydroquinone	18 gr.	(2 gm.)
Sod. carbonate (anhydr.)	26 gr.	(3 gm.)
Potass. bromide	3½ gr.	(0·38 gm.)
Water to	20 oz.	(1000 c.c.)

The time of development is to be such that an area receiving twenty times the exposure of an area developing to a density of 0·10 above fog-level shall have a density of 0·90, plus or minus 0·05, above fog-level. Development is to be carried out at 20° C. plus or minus 0·5° C.

Watkins Thermo-Developers.

Two standard formulæ, given below, were issued in connection with the tables of development times issued by Alfred Watkins and the Watkins Meter Company. They were as follows :—

Thermo Pyro-Soda.—Watkins factor 5.

A.	Pyro	320 gr.	(36·5 gm.)
	Potassium metabisulphite	160 gr.	(18 gm.)
	Sodium sulphite	4 oz.	(200 gm.)
	Water to	20 oz.	(1000 c.c.)
B.	Sodium carbonate	8 oz.	(400 gm.)
	Potassium bromide	80 gr.	(9 gm.)
	Water to	20 oz.	(1000 c.c.)

One dram each of A and B made up to 1 oz. with water is a normal developer. (12·5 c.c. of each up to 100 c.c.) If the

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bromide is omitted, the development time is practically unaltered, but the Watkins' factor becomes 12.

Thermo M.Q.—Watkins factor 15.

A.	Metol	60 gr.	(7 gm.)
	Sodium sulphite	4 oz.	(200 gm.)
	Hydroquinone	180 gr.	(21 gm.)
	Water to	20 oz.	(1000 c.c.)
B.	Sodium carbonate	5½ oz.	(275 gm.)
	Water to	20 oz.	(1000 c.c.)

1½ drams of A and 1½ drams of B made up to 2 ozs. with water make a normal developer of energy equal to that of Thermo Pyro-Soda. (9·4 c.c. of each to 100 c.c.)

Development during and after Fixing.

Proprietary solutions for the simultaneous development and fixation of films have recently been placed on the market. They have the advantage that since the fixing process sets an automatic termination to development, the time of immersion hardly matters so long as it is not too short, and temperature is unimportant because a higher (lower) temperature accelerates (retards) both processes to about the same extent. Nevertheless, the use of such a solution necessarily means that the operator is surrendering all power of control over development. This could be (but in proprietary preparations has not yet been) restored by preparing the working solution from two stock solutions, one developing and one fixing, which could be mixed in slightly different proportions according to the degree of contrast required or according to the emulsion being used.

A developer which will simultaneously fix the film can be prepared as follows :—

Sodium sulphite (anhydr.)	350 gr.	(40 gm.)
Amidol	45 gr.	(5 gm.)
Tribasic sodium phosphate	175 gr.	(20 gm.)
Hypo (crystals)	220 gr.	(25 gm.)
Water to	20 oz.	(1000 c.c.)

Take 1 oz. for each 9 sq. in. of plate or film to be developed (1½ oz. for one ¼-plate) and use at 60°-65° F. Time required, 15–18 min.

Development after Fixation.—It has long been known that in many instances an image may be developed on a plate

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which has already been fixed. All that is required is to expose sufficiently, fix in a plain hypo bath slightly alkaline, and to wash thoroughly. The clear plates which bear the invisible image may now be fully exposed to light, and the development may be postponed for any length of time. The development is in full daylight, as follows :—

A stock solution is made up with—

Distilled water	100 c.c.
Ammonium thiocyanate . .	24 gm.
Silver nitrate	4 gm.
Sodium sulphite	24 gm.
Hypo	5 gm.
10 per cent. potassium bromide solution	6 drops

This stock solution keeps well, and for use 6 c.c. of it are mixed with 54 c.c. of water and 2 c.c. of Azol, or the concentrated paraminophenol developer given under *Paraminophenol* above.

The development of the plate is slow, sometimes taking as long as 12 hours. When the development is complete, all that is required is to wash the negative ; but if the whitish tone is objected to, the negative may be blackened by the mercuric chloride process of intensification.

Diactinic. A term applied to any medium through which actinic light (*q.v.*) can pass. Substances which allow no actinic light to pass are termed *adiactinic.*

Diaminophenol. Chemical name of AMIDOL (*q.v.*).

Diaphragms (διάφραγμα, a partition) very frequently called "Stops," are obstructions placed before, behind, or within a lens to cut off marginal rays while permitting the central rays to pass.

In early lenses a form of stop devised by Col. Waterhouse was used. Stops, consisting of thin plates of metal, each with a different-sized circular opening, were placed in a slot in the lens mount in such a way as to bring the centre of the opening on the axis of the lens. In a later form, the inconvenience of having to carry a number of separate stops led to their replacement by *rotating stops*, which consisted of a circular plate pierced with a series of holes, any one of which could be brought into position by rotating the plate. A similar device,

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usually in the form of a sliding plate, is found in a number of simple modern cameras.

In all other modern cameras and lenses the *iris diaphragm* is used. This consists of a number of overlapping leaves of thin metal. One end of each leaf is located on the periphery of the mount while the other is located on a circular ring. Rotation of the latter brings the centre of each leaf towards or away from the axis of the lens, so contracting or enlarging the roughly circular free space left between the leaves.

In a doublet the diaphragm is midway between the components if they are alike, but if they are of different focal lengths the position of the diaphragm depends on their relative foci. Its position in a modern non-convertible anastigmat depends on the design of the individual lens.

The diaphragm controls the amount of light passing through the lens, and hence the exposure that the film will need. But as the cone of light (converging to a point on the sensitive surface) that will be admitted by a lens of 1 in. diameter at 3 in. from the film is identical in angle with that admitted by a lens of 2 in. diameter at 6 in. from the film, identical exposures will be required in these two instances. Exposure is thus determined by the ratio of the diameter of the aperture to the focal length of the lens, and if this is known the exact focal length of the lens needs no longer to be taken into consideration in determining exposure.

The evident convenience of this has led to the practically universal use of the " F system " of marking stops. If the focal length of a lens is 4 in. and its aperture 1 in., it is said to " work at *f*/4." The figure 4 denotes the number of times the diameter of the aperture will divide into the focal length, and the statement that " the stop is *f*/4 " indicates that the diameter of the aperture is equal to the focal length divided by 4. The symbol " *f*/4 " is thus exactly what it appears to be; a simple fraction. It is therefore rather misleading to write *f*.4 or *F*.4 (the juxtaposition suggests multiplication) as is sometimes done. On the Continent it is quite usual to give the proportion between focal length and aperture instead of the size of the aperture, so that " *f*/4 " is written as " 1:4 ". If, for example, a lens is engraved " 1:2·8/45 ", the meaning is that the widest aperture is *f*/2·8 and the focal length is 45 mm.

In the case of a compound lens, or a single lens with the diaphragm behind it, the aperture on which calculation of the *f*-number is based is measured on the front glass of the lens.

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If the lens-components in front of the diaphragm are positive (convergent) the diameter of the iris diaphragm will be less than the effective aperture. (See *Determining Effective Aperture* below.)

Any lens, of any focal length, will require the same exposure as any other so long as their diaphragms are set to the same *f*/number—apart from questions of loss of light in the lens through reflection or absorption. As the amount of light passed depends on the area of the aperture, whereas the *f*/number denotes its diameter, the exposure required at different stops will be proportional to the square of the *f*/number. At *f*/8 four times the exposure required at *f*/4 will be needed, while to find the stop requiring double the exposure of *f*/4 we must multiply 4 by 1·414, the square root of two. This stop is accordingly *f*/5·656.

The standard series of apertures with which all British and most foreign lenses are marked is so chosen that for each successive stop marked on the scale the exposure must be doubled, and *f*/4 is taken as the basis of the series. The series therefore is :—

f/1·4 ; *f*/2 ; *f*/2·8 ; *f*/4 ; *f*/5·6 ; *f*/8 ; *f*/11 ; *f*/16 ; *f*/22 ; *f*/32.

It will be observed that for convenience the numbers actually used are somewhat rounded off.

There is no compulsion on any lens-maker to turn out lenses whose maximum apertures coincide precisely with the figures of the above series, the basis of which is after all purely arbitrary. In the past, *f*/6·8 and *f*/6·3 have been the maximum apertures of many first-rate lenses, and more lately *f*/4·5 and *f*/3·5 have become exceedingly common. Particularly is this the case with *f*/4·5, which was the standard maximum aperture of the majority of fast lenses from about 1910 to 1925 or later. As a result of this, a series of apertures based on *f*/4·5 is sometimes found on lenses, notably those issued for all but the latest Leica cameras. The series in question is:—

f/1·6 ; *f*/2·2 ; *f*/3·2 ; *f*/4.5 ; *f*/6·3 ; *f*/9 ; *f*/12·5 ; *f*/18 ; *f*/25.

As with the series based on *f*/4, the exposure has to be doubled at each step.

If the maximum aperture of a lens does not belong to the series according to which the other stops are marked, it will be desirable to work out its exact relative exposure value.

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Diaphragms

If an *f*/3·5 lens is marked with the *f*/4 series, so that the figures run: 3·5, 4, 5·6, 8, etc., the rule that exposure is proportional to the square of the stop-number must be invoked. $(3{\cdot}5)^2 = 12{\cdot}25$, and $4^2 = 16$. At *f*/3·5 the exposure required will therefore be $\frac{12{\cdot}25}{16}$, or $\frac{49}{64}$, of that needed at *f*/4. The convenient round number of three-quarters would make a suitable working approximation.

In 1881 the Royal Photographic Society proposed to avoid this need for squaring by marking diaphragms by figures denoting their relative exposure values, taking *f*/4 as the unit. On the "Uniform System," therefore, the series of *f*/numbers based on *f*/4 would run :—$\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, 1 (= *f*/4), 2, 4, 8, 16, 32, 64.

This system has not been used for many years, but lenses marked according to it can still occasionally be found, notably in the oldest Kodak cameras. The same makers have often marked the lens-apertures in their less expensive cameras with the figures 1, 2, 3, 4—these are merely identifying numbers for use in connection with the instruction booklet, and the fact that the largest aperture is labelled "1" does not imply that it is U.S. 1 or *f*/4. Usually it is about *f*/11.

T-stops.—The steady tendency towards ultra-fast lenses of complicated structure, which lose much light by internal reflections, combined with the recent introduction of coating (see COATED LENSES) to eliminate these reflections, has introduced the possibility of quite large differences in the amount of light transmitted by different lenses working at the same *f*-number. This, in turn, introduces possibilities of error in exposure calculation that may be important when using colour film, the latitude of which is small. To allow for this, a new system of stop-marking, based on the actual light transmitted by the lens at various stops, has been suggested. This "T-system" (T for "transmission") is based on the *f*-system; a lens marked T 5·6 actually transmits the same amount of light as would an *f*/5·6 lens composed of ideal glasses that neither reflected nor absorbed any light at all. If the lens marked "T 5·6" is a complex one, uncoated, and in fact wastes, by reflection and absorption, some 40 per cent. of the light it receives, measurement of the effective aperture would show it to be about *f*/4·35. If the lens were now coated, reducing its losses, say, to 7 per cent., the T-number of the stop would

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be altered to T 4·5, the *f*-number of course remaining at *f*/4·35. Only if the glasses could be made *completely* non-absorbing and *completely* non-reflecting would the T-number reach the same value as the *f*-number.

At the time the T-numbers were suggested, many lenses were still uncoated, and differences in transmission could be large, but now that all multi-element lenses are coated, these differences are once again small, and T-stops have not come into general use.

Use of Diaphragms.

The connection of the diaphragm with exposure has already been made clear. Besides reducing the light passed, closing the diaphragm has a considerable effect on the character of the image.

If a perfectly corrected lens were focused on the night sky, the image of every star would be sharp, no matter what part of the plate it might fall upon. Incomplete correction of the lens would result in some or all of these images—usually those towards the margins of the field of view—being represented as discs instead of points of light. The residual aberrations responsible for this unsharpness are reduced by making the diaphragm smaller; "stopping down" would therefore result in reducing the diameter of the discs of light until they approximate to points.

Stopping down thus *improves the definition given by an incompletely corrected lens.*

Assuming that by the "night sky test" the lens were found so well corrected that stars in all parts of the field of view were sharp, next imagine the camera focused on an object say 10 ft. away. At full aperture this will be sharply rendered, but images of objects at greater or less distances will be unsharp. This lack of sharpness will be greater the further removed the object is from the 10-ft. distance focused upon. Objects at 9 ft. or 11 ft. will hardly be perceptibly less sharp, but those at 6 ft. and 30 ft. will be decidedly blurred. On stopping down the lens the zone of satisfactory definition will spread outwards in both directions from the distance focused upon, until when a sufficiently small aperture is reached even the objects at 6 ft. and 30 ft. will no longer be perceptibly less well-defined than that originally focused upon.

Stopping down thus *extends the zone of sharp focus.* (See Depth of Focus.)

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The "Best" Stop

With some lenses of extreme speed (*f*/2 or wider maximum aperture) a small amount of residual aberration is deliberately left in the centre region of the lens to balance aberrations due to the peripheral zones. If such a lens is progressively stopped down, definition may improve up to a point and then deteriorate.

This point is often overstressed, and it is worth remarking that if the loss of definition on stopping down beyond the best stop is likely to be noticeable in practice, the lens-maker will limit the movement of the diaphragm, so that it cannot be set to too small a stop. Further, though central definition may pass its best if the lens is too far stopped down, marginal definition usually continues to improve. With a miniature lens stated to give best definition at about *f*/6, it may be necessary to stop down to *f*/11 or even *f*/16 to get the sharpest reproduction right into the corners of the negative. The loss of central definition is usually too trifling to notice, even with the high-resolution films used for microfilm work.

Diffraction, sometimes blamed for loss of definition on stopping down, plays but a small part. Its effect, with a perfect lens, is to broaden out a point to a diameter of $0{\cdot}00045n$ inches, where n is the stop-number in use. For an object, exactly focused upon, to be rendered on the negative with the slight but unnoticeable unsharpness associated with the limit of depth of focus on a miniature film, the lens would have to be stopped down to about *f*/30. With larger stops the effect can safely be ignored, even on miniature negatives; on larger negatives the larger circle of confusion permissible will allow even smaller stops to be used with safety.

Determining Effective Aperture.

Occasionally it is desired to determine the effective aperture of a lens. First, the focal length must be known. If not engraved on the mount, it can be determined as described under FOCAL LENGTH (*q.v.*). The camera is next focused on a distant object, and the focusing screen is replaced by an opaque card with a pin-hole at its centre. A piece of bromide paper is cut to fit close against the front of the lens, and held in place by the lens-cap. A light is then placed behind the pin-hole for a suitable time, after which the bromide paper is developed. The black disc upon it shows the diameter of the parallel beam of rays emerging from the lens. Dividing this

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diameter into the focal length of the lens gives the *f*/number of the aperture.

Change of Aperture with Extension.

For calculating exposure it is assumed that the distance of the lens from the sensitive surface is equal to its focal length. In all exposure calculations, including those for lenses whose back focus differs widely from the equivalent focal length (telephoto lenses), estimation of the *f*/number on this basis is correct except when photographing very near objects, for which the lens is removed farther from the plate in order to get these near objects in focus. As the diameter of the aperture remains unchanged its effective *f*/number must increase.

In all ordinary photography the increase in exposure called for on this account may be neglected, for the increase only amounts to 10 per cent. when focused on an object distant from the lens by 21½ times its focal length, and does not reach 50 per cent. (the least that need be taken seriously into account) until the object is as near as 5½ focal lengths from the lens. For nearer objects than this a suitable correction should be made. (See EXPOSURE.)

It should be noticed that where focusing is carried out by changing the focal length of the lens (front-cell focusing, supplementary lenses), this correction is not required, for the distance of the lens from the sensitive surface does not change.

Diapositive or "Dia". Ordinary photograph (*i.e.*, not a negative) on a transparent support for viewing by transmitted light or for projection.

Diazotype or Primuline Process. An old process based upon the property which certain diazotised dyes possess of being so altered by light that they will not form colouring matters with certain anilines and phenols. Various colours can be obtained, and the process is applicable to paper, materials, or to gelatine on glass, but the colours are not very brilliant, nor is the ground pure white.

Dissolve 1 part of primuline in 100 parts of nearly boiling water, with constant stirring; then keep the linen, silk, plush, or velvet moving in the hot solution for 5 minutes. The dressing in linen or silk must be removed by previous washing. Drain off excess of primuline solution, rinse once in cold water,

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and dry as rapidly as possible. All this may be done in full light, and the prepared cloth may be kept indefinitely.

To sensitise, well saturate the material in a solution containing 4 parts of sodium nitrite and 6 parts of oxalic acid to 1000 parts of water, then drain, rinse, and remove superflous moisture by pressing between pads of blotting paper. This must be done in a dark-room or by weak artificial light. The material need not be absolutely dry before exposing, and must be exposed at once.

Printing is done by daylight, exposing the material under a positive for some 30 seconds in sunlight, or ten minutes or more in diffused light. To gauge exposure, expose some small pieces of material beside the frame, and continue exposing till they no longer give a colour when tested with the developer.

The developers are as follows :—

For Red Tones. β-naphthol, 6 parts, sodium hydroxide, 8 parts, distilled water, 1000 parts.

For Purple Tones. α-naphthylamine, 12 parts, oxalic acid, 1·2 parts, distilled water, 1000 parts.

For Brown Tones. Pyrogallol, 12 parts, distilled water, 1000 parts.

As soon as the colour is sufficiently developed, the material should be well washed in water, and dried.

Dichroic Fog. See Fog.

Diethylene Glycol. $(CH_2OHCH_2)_2O = 86$. Used as preservative and solvent in at least one developer of American origin, and serves also to harden the gelatine.

Diffraction. An optical term used to denote the spreading of light on passing the edge of an opaque body.

Diffuse Density. A density measured in such a way that all light scattered by the deposit whose density is being measured is collected, included in the measurement, and counted as passed by the deposit. This leads to a value lower than the *specular density*, in measuring which scattered light is counted as lost by the deposit, so adding to the density. The ratio of specular to diffuse density is Callier's factor.

In practice density is measured by the loss of light produced when the deposit to be measured is placed over an opal plate. As this already greatly scatters the light, the density so measured approximates closely to the diffuse density.

Diffusion Disc. An accessory, in the form of a lens-cap, that produces a soft-focus effect (see Soft Focus) when placed over a normal lens. The disc consists of a plain piece of glass

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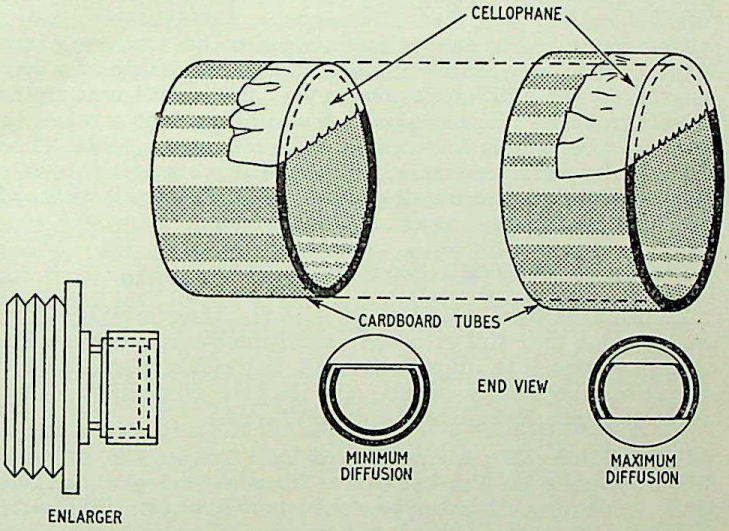
bearing a number of indentations or similar minute deformations evenly distributed over its surface, these deformations covering only a small part of the total area. Through the plane portion a normal sharp image is formed ; this is surrounded by a soft image caused by the slight refraction of the light by the surface-deformations of the disc. A home-made substitute may be built up on the lines indicated in the attached sketch, which is self-explanatory. Though shown for use on an



enlarger, the attachment can equally well be put over the lens of the camera.

DIN. See *Scheiner and DIN Speeds,* under SENSITOMETRY.

Dioptre. Unit in which opticians express the "power" of a spectacle lens. The power of a lens in dioptres is the reciprocal of its focal length in metres.

Direct-Vision Finder. See VIEW-FINDER.

Dishes for photographic purposes are usually rectangular in shape, of various depths, and are made of a variety of materials, such as glass, earthenware, plastic, metal, celluloid,

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and wood. In the case of wood and metal (except stainless steel) they are usually covered with an acid-resisting paint or varnish. Dishes for chemicals used in photography should be kept scrupulously clean by occasional scrubbing with a stiff brush and a solution of acid, such as dilute hydrochloric acid. Dishes that cannot be cleaned, especially porcelain dishes the glaze of which has chipped or cracked so as to allow chemicals to soak into the porous interior, should be reserved for one particular operation only.

Dispersion. As the refractive index of a transparent medium such as glass is different for light of different wavelengths, light of different colours will follow different paths after refraction. The analysis of white light by a prism to form a spectrum is the best-known example of this. The variation of refractive index with wavelength is not the same for all media, or even for all glasses, and advantage is taken of this in eliminating chromatic aberration (*q.v.*).

Distances, Judging. See HAND CAMERA WORK.

Distilled Water. $H_2O = 18$. Pure water obtained by vaporisation in a still or retort, and subsequent condensation of the vapour. It should be used in certain photographic operations, especially in the manufacture of emulsions and ferrous oxalate development. (See WATER.)

Distortion. The image formed by a lens on the flat surface of a plate or film can suffer from distortion of various kinds, most of which are apparent rather than real. It should be added that the apparent distortion is usually the least acceptable.

Pincushion and Barrel Distortion.—With a single lens, a square or rectangle that nearly fills the plate is reproduced, according to the position of the stop, as though the edges were bulged out from, or drawn in towards, the centre. The former effect (barrel distortion) occurs when the stop is in front of the lens, and the latter (pincushion distortion) when it is behind. The old " rectilinear " lenses were built up of two single lenses, one on each side of the stop, and with these this type of distortion was corrected. The same principle of correction is embodied in all anastigmat lenses.

Wide Angle Distortion.—An unpleasant variety of apparent distortion in which objects nearer the camera seem to be

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reproduced larger than they should be. The distortion is entirely due to viewing the print from a distance greater than the focal length of the lens with which it was taken. If, by enlarging the print suitably, or using a lens to enable it to be viewed at close quarters, the eye is placed at the correct distance, this distortion disappears. The "stereoscopic effect" often claimed for various devices that include a lens or a concave mirror to permit a small print to be viewed from a short distance is chiefly due to the elimination of wide-angle distortion. Whether recognised or not, it is always present in every small contact print normally viewed, except of course when a lens of long focus has been used in the camera.

Marginal Distortion.—Another variety of wide-angle distortion. A typical case is the elongation, along a line from centre to edge of negative, of the faces of members of a group who appear near the edges of the picture. The elongation is simply due to the fact that the light from the lens falls more obliquely on the plate towards the edges. By placing the eye opposite the centre of the print, at a distance from it equal to the focal length of the lens used, the apparently distorted faces will be foreshortened to an extent that precisely compensates for the distortion, and they will appear correctly rendered.

Distortion of Parallel Lines, or *Converging Verticals.*—A particularly noticeable variety of apparent distortion. If in taking a high building the camera is pointed upwards, vertical lines are shown converging towards the top of the print. This is a natural consequence of the fact that the top of the building is further away, and the convergence in this case is just as correct, or incorrect, as in a photograph taken looking along a railway track, where the two parallel lines come closer as they recede. But although the eye expects receding railway lines to appear to converge, it is extremely reluctant to accept the same effect in the vertical lines of a building. The unwelcome convergence of verticals can be avoided by keeping the back of the camera vertical and raising the lens well above the centre of the plate, either by using a rising front or by tilting the camera and using a swing back movement. With a vertical plate the natural convergence of the receding verticals is exactly offset by the broadening effect of marginal distortion (see above), and the lines are rendered parallel, though the apparent height of the building is increased. This version, though by no means an undistorted one, is very much more acceptable to the eye.

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It should, however, be recognised that the elongation of a building due to marginal distortion is considerable when a rising front is used, as the light forming the image of the top of the building falls on the sensitive surface at a more acute angle than when the lens is central. The magnitude of the elongation may be quite large; for example, with a 4-inch lens opposite the top of a quarter-plate, an object just included at the top of the picture will be drawn out to about one and a half times its proper length.

In interpreting this figure it should be borne in mind that it represents the ratio of the actual length of the image (as measured or viewed by parallel light) to the correct length as it appears from the point of view of the lens. From this point of view there is, however, necessarily some foreshortening of those parts of the object whose image falls at the margin of the plate; the elongation precisely compensates for this. If the object is a plane surface parallel to the plate (e.g., a diagram or photograph being copied) the final image, viewed by parallel light, is an undistorted reproduction of the original object as it would appear if similarly viewed. But with any object in three dimensions the distortion of perspective is usually very evident.

We therefore have to conclude that though a photograph of a tall building from ground level can be made to show parallel verticals by using the rising front, the resulting image must show considerable distortion unless viewed from a distance equal to the focal length of the lens, and from a position opposite that part of the image that was on the axis of the lens when the picture was taken. From this viewpoint the verticals will no longer appear parallel, and the perspective will be identical with that obtainable, much more simply, by tipping up the camera and dispensing with the use of the rising front. (See also PERSPECTIVE.)

Correction of Distortion.—It is possible, but by no means easy, to prepare, from a negative taken with the lens central and the camera tilted, a print identical with one that would have been obtained with the camera-back vertical and the lens raised. This must be done by projection, tipping both negative and paper in such a way that the image remains sharp all over without stopping down. Accurate correction can only be obtained if the negative and paper are de-centred with respect to the axis of the lens. Neglect of correct adjustment in this respect will give parallel verticals only at the cost of making the image too long and drawn-out or too short and squat.

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Details are too elaborate for ordinary amateur practice, and in any case the final result is, as we have seen, only to exchange an apparent distortion for a real one. In practice, it is usually sufficient simply to tilt the paper until the verticals are parallel, which in most cases gives a result as satisfying to the eye as any other. For fuller details, see *The Photographic Journal*, March, 1942.

Document Reproduction. See COPYING and REFLEX COPYING.

Dodging. See *Shading and Double Printing*, under ENLARGING.

Dolmi. Trade name for amidol marketed by Kodak Ltd.

Dope. Transparent medium frequently applied to matt bromide prints or enlargements to reduce the proportion of scattered light reflected, and so increase the apparent depth of the shadows and improve the gradations of the deeper tones. A suitable mixture is :—

Mastic varnish	1 part
Linseed oil	1 part
Turpentine	2 parts

All should be of "artist's quality." The dope is applied with a wad of cotton-wool, and after being allowed to soak in for a few moments, the excess is polished off with a fresh piece of cotton-wool. If the dope dries too slowly, reduce the proportion of linseed oil. (See also ENCAUSTIC PASTE, MAGILP, and *Retouching and Finishing Bromides*, under BROMIDE PAPER.)

Double Anastigmat. Anastigmatic doublet (*q.v.*) made up of two components each corrected for astigmatism. Either of the two components can be used alone as a long-focus lens if the necessary extra camera extension is available.

Double-coated Film. A film with two emulsions, a slow one next the base and a fast one on top of it. This confers great exposure-latitude, but at the cost of considerable loss of acutance.

Double Extension. A double extension camera is one in which the bellows and the forward travel of the front are such as to allow the lens to be placed at a distance from the plate or

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film equal to not less than twice the focal length of the lens. This allows the camera to be used for copying objects at life-size, and permits a single component of a convertible lens (*q.v.*), to be used for long-focus work.

Double Transfer. See CARBON PROCESS.

Doublet. A lens consisting of two components of similar type. Each may be a single non-achromatic lens, an achromatic (landscape) lens, or a more elaborate combination of glasses. The earliest was the "rapid rectilinear" (R.R.), a once popular construction consisting of two achromatic lenses of the same or different focal lengths. Many lenses of this type, often with fancy names, have been made in the past. Doublet anastigmats include the Zeiss Protar, the Ross Combinable, and the Watson Holostigmat, either component of which can be used separately as a long-focus lens. The doublet construction is now seldom used except for such lenses as those just mentioned.

Drachm or Dram. See WEIGHTS AND MEASURES.

Drawings from Photographs. By first drawing, in pencil or waterproof ink, over the outlines of a print, and then removing the image by chemical means, any photograph can be converted into a drawing. A soft high-key print on smooth matt paper is best as basis for the drawing, but a normal print should also be made to act as a guide.

Place the high-key print on a drawing-board, and mark over the main outlines with a sharp hard pencil; detail can be inserted later. Then treat the print in a 5 per cent. solution of potassium iodide in which has been dissolved enough iodine to give a rich port colour. When the image is bleached as far as it will go, rinse the print in several changes of water, fix in acid hypo, wash, and dry. A ferricyanide and bromide bleacher, as used for sulphide toning (see TONING), may be used in place of the iodine bleach, but the print must be protected from any but weak light until it is fixed, or a faint trace of the image may remain.

The print, now bearing only the faint pencil lines, is next mounted, and the drawing is completed as the taste of the draughtsman directs. The outlines on the bleached print, together with the normal print kept as a guide, between them make the work easy. The drawing may be done in either pencil or waterproof ink, and any desired modifications may

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be made. A drawing in pencil can be fixed by passing the paper backwards and forwards through the steam from a kettle, or by applying an artist's fixatif. If fixed ink is used the drawing can be tinted with water colours, giving the effect of a coloured etching or tinted engraving. It is not easy to lay large flat washes on the gelatine surface of the paper, but these are practically never required. Small areas of broken colour are more usual, and much can be done by applying several light tints successively with intervals for drying. Another plan is to apply a few simple washes on the original faint outline, and then work up with pencil over the colour.

The following method, in which the drawing is made direct on drawing paper, without the intervention of any photographic image, has been suggested by Leonard Misonne. The negative is projected to the desired size on drawing paper in a completely darkened room. If the paper is then shaded with pencil, stump, or crayon until it appears uniformly dark all over, it will be found, on turning out the enlarger and lighting the room normally, that the paper bears an exact copy, in positive, of the negative, and that this copy has the same contrast as the projected image of the negative. Modification of all kinds can evidently be carried out, either on the enlarging easel or afterwards.

Drop Shutter. An obsolete type of SHUTTER (*q.v.*).

Drops. It is almost a tradition among photographers to reckon one drop equal to one minim, but by so doing serious inaccuracies may be produced. Before measuring in drops, first find how many drops are required to fill a measure to the one-drachm mark. In this way the necessary correspondence between drops and minims can be established. For the same liquid, dropped in the same way from the same bottle, this relationship is sufficiently constant for photographic measurements, except perhaps with highly viscous liquids. With aqueous solutions (*e.g.*, 10 per cent. bromide) it is usually found that one drachm (60 minims) contains from 35 to 50 drops, the exact figure depending on the bottle used. A dropping bottle is the most reliable for constancy.

Droxychrome. Trade name of colour developing agent manufactured by May & Baker. (See COLOUR DEVELOPING AGENTS.)

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Dry Mounting. See MOUNTING.

Drying Negatives and Prints. Drying negatives after washing is a straightforward operation, yet one or two serious troubles may arise if a few simple precautions are not taken. Drying marks and dust are the chief dangers.

It is worth noting that if the film has been well hardened during processing (preferably with chrome alum) the gelatine is made so much more compact that dust sits on the surface (and can be brushed off after drying) instead of becoming deeply embedded in the gelatine. Also drying takes much less time.

The film should be hung up in a dry room, and excess water wiped off both sides with wet chamois leather, a viscose sponge, or even the fingers. Adhering drops, if left on while the negatives dry, take so long to evaporate that a change in density may occur locally. Drying marks are formed in this way. Note that 35-mm. films have no gelatine backing ; the back of these may be dried with a soft cloth.

If a wetting agent (*q.v.*) is included in the last wash-water, adherent water may be expected to drain off without leaving droplets. Wiping is then unnecessary.

Since the process of drying consists in leaving the water to evaporate, which it will not do if the atmosphere of the room is already charged with moisture, a dry room must be chosen. If it is also warm, so much the better, but negatives will dry much faster in a cool, dry room than in a warm one with a humid atmosphere.

Draughts almost inevitably stir up dust, which will adhere to the gelatine in the sticky, half-dry stage. Drying should therefore be done in still air. This point is particularly important with miniature films ; the dust is often practically invisible except in an enlargement.

In drying cut film or film-pack negatives it is best to pin them up by one corner to a shelf, wipe down, and after a few minutes to blot off the drop that will have collected on the lowest corner.

Plates should be placed, well apart, in a drying rack, first wiping the glass side dry with a cloth. Excess moisture on the emulsion side should be removed as from cut film negatives. If no rack is available they may be stood on blotting-paper on a shelf.

Prints may be pinned to a shelf, hung from a line by means of clips, or laid face downwards on butter-muslin stretched

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on a frame. A more convenient, but less desirable, method is to lay them face up on towels spread on the floor. Whatever method is adopted, excess moisture should first be removed by going over them, on an absorbent surface, with a roller squeegee. A single negative or print wanted in a hurry may safely be dried by waving it continuously in front of a fire at a distance such that a print on double-weight paper, with both sides freely exposed to the air, dries in four or five minutes. A negative will dry in about 3 minutes.

Rapid Drying may be attempted by hardening negatives in a 1 per cent. formalin solution, rinsing in hot water, mopping off superfluous moisture, and drying by moderate heat. Plates and films may be dried by immersion for 2 or 3 minutes in methylated spirit, not stronger than 80 per cent.; in a brisk current of air negatives so treated will dry in a very few minutes.

It is nowadays usual in press work to print by enlargement from the wet negative, which is afterwards dried at leisure, and the amateur may well follow the same method. Prints may be dried by squeegeeing off superfluous moisture, and then drying in front of a fire as suggested above, or by a blast of hot air from a hair drier.

Dry Plates. Glass coated with an emulsion of silver salts in gelatine. Called " dry " to distinguish them from the long obsolete " wet " plate. (See WET COLLODION PROCESS.) In everyday parlance they are simply referred to as " plates." (For Sizes of Dry Plates, see SIZES, PHOTOGRAPHIC. See also EXPOSURE and SENSITOMETRY.)

Drying Rack. A grooved, trough-shaped rack for holding glass negatives. (See DRYING NEGATIVES AND PRINTS.)

Dry Stripping Paper. A special bromide paper made by Ilford Ltd., the image on which can be transferred, dry, to any suitably-prepared surface. (See also TRANSFEROTYPE.)

Dufaycolor. See COLOUR PHOTOGRAPHY.

Dust Spots. See PINHOLES.

Dusting-on Process. See POWDER PROCESS and PEPPERTYPE.

Dyeing, Photographic Prints by. There are several methods of making photographic prints on textiles by true mordant dyeing. For example, calico or linen may be sensitised by moistening with a 1 to 10 solution of ammonium bichromate. When dry, expose under a negative and wash.

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The image now consists of mixed oxides of chromium, and if the textile is boiled for ten minutes or so in a 1 to 3600 solution of alizarine, the dye will deposit on the oxide of chromium. The impression should be cleared by boiling in soap and water. (See DIAZOTYPE. See also COLOUR-FORMING DEVELOPERS.)

Dye Transfer Process. A Kodak process for making colour prints from separation negatives. (See COLOUR PHOTOGRAPHY.)

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E

Eberhard Effect. At a meeting-place of highlight and shadow on an exposed film, unexhausted developer from the shadow area develops the edge of the highlight more than the rest of it, and, similarly, exhausted developer from the highlight area slows development at the edge of the shadow area. This increases apparent sharpness, but if too marked makes a noticeable line round the highlight. The effect is most evident if the developer was stagnant, and with sufficiently vigorous agitation of the developer it cannot appear at all.

Ebonite. A modification of indiarubber made by heating it with sulphur under pressure. Sometimes used for making dishes, the leaves of shutters, etc., and, though brittle and affected by heat, answers well, from its great lightness and hardness. (See DISHES.)

Eburneum Process. See IVORYTYPE.

Edge Effect. (See EBERHARD EFFECT and MACKIE LINE.)

Edinol. Oxymethylparaminophenol sulphate $(CH_2OH)(OH)C_6H_3(NH_2)_2^1H_2SO_4) = 188$. Developing agent of moderate activity. Has not been available since 1914. (See DEVELOPMENT.)

Efflorescence. Loss of water of crystallisation, as a result of which the crystals disintegrate on the surface to form a powder. The behaviour of crystals of washing soda (crystallised sodium carbonate) in the air is an example.

Eikonogen, Sodium amino-naphthol sulphonate $(NH_2\text{-}OH)C_{10}H_5(SO_3Na)2\frac{1}{2}H_2O = 306$. Developing agent of high activity. Considerably used previous to 1914, but now no longer available except perhaps in Germany. (See also DEVELOPMENT.)

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Electric Light. The chief light-sources used by the photographer, apart from daylight and the various types of flash, are ordinary household electric lamps, the special "photoflood" lamps, and studio lamps. The output of all these is commonly expressed in lumens (*q.v.*), and it is important to notice that the lumen is strictly a visual unit. As the light of all electric lamps is yellower than daylight, and as all films, even panchromatic ones, are more sensitive to blue light than is the eye, the photographic effect of a lumen of electric light is less than that of a lumen of sunlight.

For the purpose of calculating exposure it is more than sufficiently accurate to assume that, with any type of electric light, a panchromatic film will require 160 lumens, and a modern highly orthochromatic plate about 250 lumens, to equal 100 lumens of sunlight. A plate that is not even orthochromatic will need some 500 lumens of electric light to equal 100 lumens of sunlight, so that if such a plate and a panchromatic film required the same exposure (*i.e.*, were of equal speeds) in daylight, the film would require, by electric light, an exposure less than one-third of that required by the plate.

The output of light given for each watt of electrical power consumed depends on the temperature reached by the filament of the lamp. (See COLOUR-TEMPERATURE.) The higher the temperature the greater the light output—but also the shorter the life of the lamp. A household lamp (average life 1000 hours) gives about 12 lumens per watt; in a photoflood lamp, the filament of which runs at so high a temperature that the average life is only 2 hours, the output per watt is nearly three times as great. More detailed information is given in the table below, which gives the approximate output in (visual) lumens for the lamps usually met with.

Lamp	*Probable Life (hours)*	*Lumens per Watt*	*Total Lumens*
Vacuum			
25 to 40 watts	1000	9	225 to 360
Half-Watt (or Gas-filled)			
40 watts	1000	11	440
60 watts	1000	12	720
100 watts	1000	13	1300
150 watts	1000	14	2100
250 watts	1000	15	3750
500 watts	1000	16	8000

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Lamp	*Probable Life (hours)*	*Lumens per Watt*	*Total Lumens*
Studio lamp			
500 watts	100	21	10,500
Projector Lamps			
3 amps.	100	21	—
5 amps.	100	22½	—
10 amps.	100	23½	—
Photoflood No. 1			
275 watts	2	29	8000
Photoflood No. 2			
500 watts	6	30	15,000

See also OVER-RUN LAMPS.

Electrolytic Development. It is found that if a photographic material of the silver halide type is exposed and subsequently bathed in an ammonia solution containing a trace of a suitable metallic salt, a visible image may be produced by placing the emulsion in intimate contact with a copper plate. For further details, including the theory of electrolytic development, see R. S. Morse, *J. Franklin Inst.*, (1939), **228**, 169–175.

Electronic Flash. Flash obtained by an electrical discharge through a tube, filled usually with xenon under reduced pressure, and known as a flash-tube. The basic circuit common to all types of electronic flash outfits includes a storage condenser of large capacity (C_1 in Fig. 1) which is charged, from a dry battery or other source, to a voltage that is not high enough to cause a discharge to take place through the gas of the flash-tube, to the terminals of which it is connected. When it is desired to fire or " trigger " the flash, a high-voltage pulse is applied to the tube, often by way of an external electrode in contact with the outside of the tube; this ionizes the gas, causes it to conduct, and allows the energy stored in the condenser to drive a heavy momentary current through the tube, thus producing the flash.

The diagram shows a common form of triggering circuit; the condenser C_2 is charged to the full supply voltage through the high resistance of R_2, and when the firing contacts F.C. (usually located in the camera shutter) are joined, the energy stored in this condenser is discharged through the primary of the triggering coil T.C. This is in reality a step-up transformer of high ratio, and the current through the primary causes a potential of some 4000 volts to appear momentarily across

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the secondary, which is connected to the triggering electrode of the tube. The resistance R_2, of about 250,000 ohms or more, serves to prevent the battery from being virtually short-circuited through the firing contacts during the period (usually very short) when they are closed; such short-circuiting would destroy the delicate contacts of the shutter-mechanism. When a voltage in excess of about 300 is used, C_2 is normally fed from the junction of two high resistances connected across the main voltage supply, their values being so chosen that the voltage actually on the condenser is still only some 300 or less. (Compare Fig. 2.) The energy stored in C_2 is so minute that the user can receive no appreciable shock.

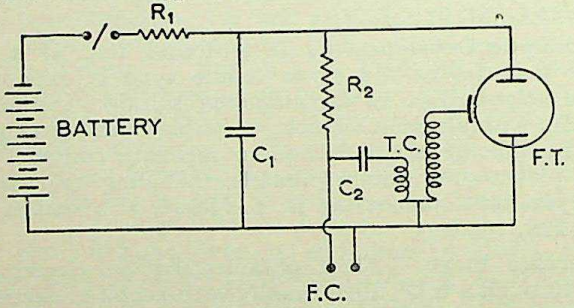

FIG. 1.

British Standard 3205/1960 is even more cautious than these suggestions; it lays down that the open-circuit voltage across the trigger contacts shall not exceed 150 volts, and that the energy discharged through the camera contacts shall not exceed 10 millijoules. This, at 150 volts, means that C_2 must not have greater capacity than about 1 mfd. At 300 volts, the maximum capacity would be 0·25 mfd. Further, it is specified that the resistance of R_2 (or that of R_3 in Fig. 2) should not be less than 2000 ohms for each volt on the storage condenser. This limits the steady current to 500 microamps for the protection of the synchronized contacts in the shutter.

The energy stored in C_1, the reservoir or storage condenser, depends both on its capacity and on the voltage to which it is charged, and is stated in joules or watt-seconds, which are alternative names for the same unit. It can be calculated, for any given case, by squaring the voltage, multiplying the figure so obtained by the capacity in microfarads, and dividing the result by two million. From this it is evident that the same stored energy can be obtained either by charging a

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condenser of large capacity to a moderate voltage or by using a high voltage and a condenser of small capacity. For the storage of 50 joules of energy (an entirely practical figure for a small amateur outfit) one might use a battery or other source of 180 volts and a condenser of 3100 mfd., or a voltage of 2500 with a capacity of only 16 mfd. There are, of course, intermediate choices; flash-tubes are available for voltages of 1000, 500, and 300 as well as those just mentioned.

From the point of view of the user, the main consideration that might control the choice of voltage is the duration of the flash. This is always short, but for photographing really fast-moving objects the higher the voltage the better. A 100-joule flash driven by a voltage of 2500 will probably last about 1/8000 second, but a 180-volt flash of the same energy would last perhaps 1/600 second. From these figures it will be evident that the speed of the flash is always high enough to preclude subject-movement or camera-shake with any normal subject, but when photographing, for example, birds or insects in flight a high-voltage flash would be preferable. For special applications, such as ballistic research, flashes of duration a millionth of a second or less can be had; this implies a very high voltage and a condenser (and circuit) in which inductance and resistance have been reduced to a minimum.

For voltages of 500 and below, special electrolytic condensers, which provide high capacity with a minimum of bulk and weight, have recently been developed. Flash outfits are rated on the basis of the energy stored in the condenser; not all of it is actually delivered to the tube. Some is wasted as heat in the internal resistance of the condenser and the connecting leads, some remains in the condenser as a residual charge. For these reasons the special "flash" condensers *must* be used; the ordinary general-purpose electrolytic condenser is not capable of delivering a high enough proportion of its stored energy to the flash-tube in the very short time involved.

For outfits working at voltages of 180 to 270, dry batteries can well be used as the source of energy; the resistance R_1 of about 500 ohms is included in the circuit to limit the initial surge of current into the uncharged condenser. For higher voltages it is more usual to use a 2-volt or 4-volt accumulator operating a vibrator device (see Fig. 4) or an oscillating circuit based on a pair of transistors; either causes the current to reverse in direction many times a second. This current is

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passed to a transformer that steps it up to the required voltage, after which it is converted to uni-directional current by a metal rectifier and so led to the storage condenser. Alternatively the primary of the transformer may be fed from A.C. mains, or the accumulator replaced by heavy duty dry batteries of voltage 4½ to 12, according to the designer's preferences. For the average amateur, who is prone to use his flash intensively for a few days or for some particular occasion, and then to put it on one side and forget it for several months, this use of low-voltage dry batteries is likely to prove the most economical of all (except A.C. mains) since a battery of voltage 180 to 270 costs a pound or so to replace, and an ordinary lead accumulator, which costs even more, will speedily become unserviceable if neglected. Low-voltage batteries, however, can be replaced for only a few shillings.

Most modern flash-units, in consequence, use either low-voltage dry batteries, or, more often, a nickel-cadmium accumulator which can withstand long periods of neglect without serious harm. A device allowing the accumulator to be recharged from A.C. mains is normally either included in the unit or supplied with it. An operating voltage of 500 is most commonly adopted, as the energy-weight ratio of electrolytic condensers is highest at about this voltage.

As already indicated, it is not altogether safe to regard the energy stored, in joules, as a precise index to the light output of an electronic flash outfit, but up to the moment there is no better guide. The energy actually delivered to the tube is converted into light at the rate of about 50 lumen-seconds per joule. Thus a 100-joule flash may be expected to give some 4500 to 5000 lumen-seconds, which is slightly less than the output of the smallest expendable flashbulb. For the average amateur, using a fairly fast film and a camera small enough to allow him to open the lens to *f*/5·6 or *f*/4·5 without too much loss of depth of focus, quite a low-power flash, of 50 or even 25 joules, is perfectly adequate for all monochrome work.

Synchronization of an electronic flash to a shutter is easy, because the response of the circuit to the closing of the firing contacts F.C. is practically instantaneous—there *is* a delay, but it amounts only to a few millionths of a second. In consequence it is only necessary to attach the triggering leads to a shutter that closes a contact at the instant the shutter-blades first reach the full-open position. Even if the shutter is set to 1/500 sec., the flash will be all over before it begins

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to close, so that synchronization is perfect at every shutter speed. All modern between-lens shutters with non-adjustable synchronization make their firing contact as described, as do those with adjustable synchronization when set to " X."

Focal-plane shutters, on the other hand, which attain short exposures by the passage of a narrow slit across the film, cannot be used with electronic flash at their higher speeds; the flash is so brief that only the part of the film that happened to be behind the slit at the instant of firing would be exposed. The shutter must therefore be set to a speed that corresponds with a slit wide enough to uncover the whole area of the film at the same time; this is usually the longest (unbraked) instantaneous speed, which in most such cameras is 1/25 to 1/50 second. Contact must be made just as the leading blind has fully uncovered the film.

There are some peculiarities which it is as well to know in the response of the film to the very brief flash of the high-voltage electronic outfits. The speed of a film is measured on the basis of an exposure of about 1/50 sec.; owing to failure of the reciprocity law, speeds so measured are not necessarily correct when the exposure is 1/1000 sec. or less. As a result, two films of equal speed rating may have very different effective speeds towards a fast electronic flash. Experiment with the individual film to be used is therefore necessary in determining exposures. A further peculiarity is that with all films, exposures much shorter than 1/1000 sec. give, with normal development, negatives of very much lower contrast than would be expected; film exposed using a high-voltage electronic flash therefore needs considerably prolonged development. It is usual to specify an increase of 50 per cent. in development time, which means that daylight and flash pictures cannot conveniently be taken on the same film.

These considerations do not apply, however, to the flash units normally supplied for amateur use; most work at 500 volts or thereabouts, and give a flash of duration decidedly longer than 1/1000 second. When working with them, relative film-speeds and development times are normal; daylight, flashbulb and electronic flash exposures may safely be mixed on the one roll of film.

For the reasons already detailed, it is not possible to base exact exposure-data on the rated energy in joules. A useful approximation, however, can be had from the formula $F = 1{\cdot}25\sqrt{JW}$, where J is the energy in joules and W the

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Weston or A.S.A. speed of the film in use. The flash-factor F so found is the product of the flash-to-object distance in feet and the *f*-number of the stop required to give correct exposure. The flash is in all cases so fast that shutter-speed does not enter. Thus with a 50-J flash and a film of speed 100 Weston, $F = 1{\cdot}25\sqrt{5{,}000} = 1{\cdot}25 \times 70 = 90$ approx. At a distance of 10 feet, the lens should be set to *f*/9. The formula assumes a reflector-factor of 6 (which means a fairly good reflector) and the conversion of electrical into light energy at the rate of 50 lumen-seconds per joule.

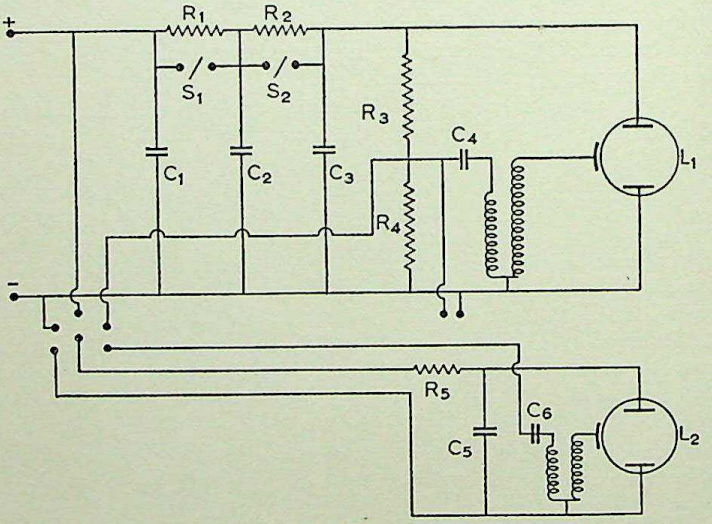

FIG. 2.

Fig. 2 shows the basic circuit of a versatile flash-outfit suitable for home construction. The main storage condenser has been broken up into three separate units separated by resistances of 200 ohms each bridged by on-off switches. All sections charge up to full voltage, but only those connected to the tube L_1 without an intervening resistance will contribute their energy to the flash. By manipulating S_1 and S_2, three different flash-energies are available. R_3 and R_4 should total about one megohm, the junction being chosen to charge C_4 to about 300 volts. (Compare Fig. 1.) A three-pin socket

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permits the attachment of a second lamp, firing with the first and equipped with its own storage condenser C_5 and 200-ohm resistor R_5 to isolate the tube from C_1. If R_5 and C_5 are omitted, L_2 will receive any energy stored in C_1 and C_2 that is not permitted by R_1 and R_2 to reach L_1.

Figs. 3 and 4 show power-sources to be connected to the input terminals of Fig. 2; Fig. 3 shows a simple high voltage battery with on-off switch and limiting resistance R_6 of 500 to 1000 ohms. Fig. 4 shows the connection for accumulator, low voltage battery, or A.C. mains. T is a transformer across the secondary of which is C_7 (0·1 mfd.) to absorb peak voltages; primary P_1 is for direct connection to the mains. Primary P_2 is a low-voltage centre-tapped winding to be fed from the vibrator V, which interrupts and reverses the direction of current from the accumulator or low-voltage high-current battery A. R is a metal rectifier to convert the alternating voltage on the transformer secondary into the uni-directional voltage necessary to charge the storage condensers.

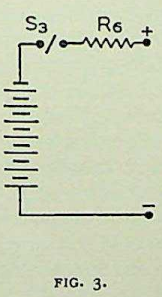

FIG. 3.

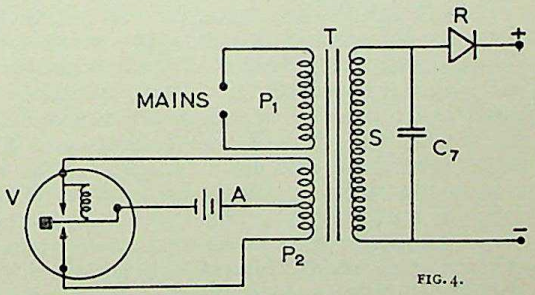

FIG. 4.

Factory-made flash outfits offer no danger, but the intending constructor should note that a charged storage condenser can deliver a dangerous, and possibly lethal, shock, especially if the outfit uses a high voltage. Extreme care should be taken to discharge the condenser, either through a resistance or by directly short-circuiting it, before touching the terminals or wires connected to them. It is not always enough to discharge the condenser through the flash-tube; there often remains sufficient residual charge to give a rather startling, though harmless, shock.

Electrotyping. The formation of metal casts from a solution of the metal by electrolytic action, and largely employed

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in connection with the production of photo-mechanical printing plates. (See PHOTO-MECHANICAL PRINTING PROCESSES.)

Element. In chemistry a substance regarded as simple or non-decomposable. In optics often applied to one glass or lens of a complex system; occasionally to an achromatised group in a system.

Eliminators, Hypo-. See HYPO ELIMINATOR.

Elon. Trade name for metol marketed by Kodak Ltd.

Emulsions. The sensitive emulsion with which films, plates and papers are coated is actually a suspension of sensitive silver salts in a protective carrier or vehicle of a colloidal character. The silver halides which are sensitive to light are the bromide, chloride and iodide, and the colloid used as a vehicle is gelatin. Collodion is used for certain emulsions used in the photo-engraving trade, and recently attention has been paid to the possible use of synthetic resins.

Fast emulsions are made by precipitating silver bromide, with a small amount of iodide, in a weak solution of gelatin; the emulsion or suspension so made is subjected to a ripening process during which the minute particles of silver halide precipitated increase in size, and a certain amount of colloidal silver is formed within some of the grains. The grains have a crystal structure, and are octahedra. They vary in diameter from 0·1 μ (μ being one thousandth part of a millimetre), to 4 or 5 μ in the largest grains. By means of the electron microscope it has now been shown that these grains when developed are not mere solid "lumps" of reduced silver as previously thought, but have the appearance of tangled ribbons and are not therefore absolutely opaque. Some idea of the size of the grains can be had from the fact that several thousand millions are contained in a single drop of an average emulsion.

Slow emulsions such as are used for coating papers are suspensions chiefly of silver bromide; for warm-tone development papers a mixture of the bromide and chloride is used, often with the addition of a dye sensitizing the emulsion to blue-green or green, while for contact papers an emulsion of plain silver chloride is employed, the grain size being relatively minute.

In making a fast negative emulsion, a solution of gelatin in water, containing soluble bromide and iodide, is first prepared, and usually at least two solutions of silver nitrate, one of

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which is treated with ammonia until the brown precipitate of silver hydroxide at first formed just disappears or is "re-dissolved." A typical formula is as follows:—

Salts Solution

Water	10 oz.	(250 c.c.)
Ammonium bromide ..	1 oz.	(25 gm.)
Ammonium iodide ..	20 gr.	(1 gm.)
Gelatin	96 gr.	(5 gm.)

Re-dissolved Silver Solution

Silver nitrate	$\frac{4}{5}$ oz.	(20 gm.)
Distilled water	1 oz.	(25 c.c.)

0·880 ammonia is added slowly, stirring with a glass rod, until sufficient to convert the precipitate and give a clear solution.

Plain Silver Solution

Silver nitrate	$\frac{4}{5}$ oz.	(20 gm.)
Distilled water	4 oz.	(100 c.c.)

The gelatin is soaked in the "salts" solution for half an hour, and the containing vessel is then warmed in a water bath or saucepan, stirring from time to time until the gelatin has all dissolved. Meantime the re-dissolved silver solution is cooled to room temperature (65° F.). The gelatin-salts solution and plain silver solution are both heated to 100° F. Proceedings take place from this time onwards in red light. The first silver solution is poured through a funnel fitted by a rubber tube with a jet of about 3 millimetres bore (a short piece of barometer tubing of this bore is convenient), while the jar containing the gelatin-salts solution is stirred briskly with a thick glass rod. A fine precipitate of silver bromide is thus formed in the gelatin solution. After an interval of half a minute or so the plain silver is added, again with brisk stirring. A further precipitate of silver halide is thus formed, the following equation indicating the reaction:—

$$Ag{\cdot}NO'_3 + NH_4{\cdot}Br = AgBr\downarrow + NH_4{\cdot}NO'_3$$

The temperature and concentration of the various solutions, the rate of emulsification, and the viscosity of the salts solution, have an important effect upon the size and nature of the grains. The amount of bromide used is somewhat in excess of that required for reacting with the silver nitrate, and as silver bromide is slightly soluble in ammonium bromide solution, some crystal growth of the minute grains takes place, added

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to which the larger grains absorb, so to speak, some of the smaller ones and increase in size at their expense (Ostwald ripening).

It will be seen from the above equation that ammonium nitrate, NH_4NO_3, is formed as a by-product, and this, together with any ammonia in the emulsion and any excess of free bromide, must be removed by a process of " washing." When the ripening is complete, which may take up to sixty minutes, more gelatin is added, usually in the dry form, and is stirred in until completely dissolved. In the above formula, $3\frac{1}{4}$ ounces (or 80 grams in the metric formula), would be added, and when dissolved,—say in fifteen minutes' time with stirring,—the emulsion would be cooled by standing the jar in cold water, or ice water, where it is left for twenty-four hours.

It will have set to a stiff jelly, and this must be broken up into shreds or noodles for washing. Commercially, this is done by squeezing the jelly under hydraulic pressure through a silver plate perforated with a number of holes about $\frac{3}{16}$ inch diameter, and letting the shreds drop into cold water. On a small scale the shredding can be done by squeezing the jelly through a piece of strong mosquito or embroidery netting, which has been first washed free of dressing. The shreds are suspended in a muslin bag in a large jar of water, and the water is drained off and changed every three to five minutes. Twelve such changes of wash water and drainings usually suffice to complete the process. If all ammonia is removed, the *p*H if taken should be about 8 or less. The washed shreds are thoroughly drained, and are then re-melted in a clean jar, and the emulsion raised to a temperature of 120° to 125° F.

The re-melted emulsion is cooked or digested at this temperature for a time varying from twenty minutes to a couple of hours, depending on the particular formula and make of gelatin. The best time can only be found by actual trial, taking away small quantities for coating a test every 15 minutes. One hour might be given with the above formula. In works practice the temperature is maintained by placing the jars in thermostatically controlled water baths, though for small scale experiments a Thermos flask, previously warmed with hot water, will be found to answer admirably.

During this digestion a profound change occurs. The emulsion increases enormously in speed, and greatly in contrast, the increased sensitivity being largely due to the adsorption from the gelatin of sensitizing compounds such as allyl isothiocyanate, which are present in gelatins, and deposit

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on the crystals forming sensitive specks or nuclei. No increase in *size* of the grains takes place, though there may be some aggregation, giving rise to graininess in the ultimate negative.

When the emulsion has been sufficiently digested, it is transferred to a cold jar, and the " finals " added. These are

(i) alcohol, to make the emulsion flow easily,
(ii) chrome alum, to prevent frilling, blistering, etc.
(iii) some free bromide, which is needed to stabilize the emulsion and prevent fog.

The washed and finished emulsion described should end up in bulk about 40 ounces (or 1000 c.c.), after the addition of

Rectified spirits	2 oz.	(50 c.c.)
5 per cent. chrome alum solution	$\frac{2}{3}$ oz.	(10 c.c.)
10 per cent. potassium bromide solution ..	$\frac{1}{6}$ oz.	(5 c.c.)

The emulsion is finally filtered through swansdown, or two thicknesses of plain lint, or better still through chamois leather. It is then ready for coating.

It must be understood that commercial emulsions are handled in a manner totally different from that possible in an amateur dark-room. Mechanical stirring during both making and washing may be given, and the times of ripening and digestion are regulated by careful preliminary investigation depending on the formula and the gelatins used. When we remember that with these few ingredients, silver nitrate, ammonium or potassium bromide, chloride and iodide, gelatin and ammonia, we can produce an immense range of photographic emulsions from slow contact papers to films and plates of 600 A.S.A., it will be realized how highly refined the control of both formula and treatment must be. To-day, organic stabilizers make it possible to push emulsions for greater speeds, with or without the addition of super-sensitizing dyes, and one result is that materials with the fine grain previously associated with comparatively slow emulsions can be speeded up for snapshot photography, a thing of the highest importance in miniature work.

The formula given above, if carefully made, should have a speed when coated on glass of about 10 to 12 A.S.A.; in other words, it represents a rather slow negative emulsion. For the purpose of making lantern slides or bromide papers, the following modifications would be made,—the gelatin in the

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salts solution might be increased 5 to 10 times, emulsifying therefore in a much more viscous solution. In the negative formula the silver nitrate is divided into equal parts, one being dissolved with ammonia, the other used plain. In a slow bromide emulsion $\frac{1}{5}$ ounce or 5 grams only of the silver nitrate might be treated with ammonia, the remainder of the silver being added as a plain solution, its distilled water being at least doubled. The ripening time would be reduced to about 5 minutes. Otherwise the entire procedure would be much the same, except that the final bulk of the emulsion would be increased by the addition of, say, 50 per cent. more water. This increase in volume would reduce the viscosity of the emulsion to a suitable degree for coating.

On these simple lines emulsions having an extraordinarily wide range of speed, contrast and quality can be made and studied. The purest chemicals only must be used, extreme cleanliness must be observed throughout, and temperatures controlled with the utmost care.

We have next to consider the nature of orthochromatic and panchromatic emulsions. A plain silver iodo-bromide emulsion such as has been described is sensitive only to the violet, blue and greenish-blue rays of the visible spectrum. The Grotthus-Draper law tells us that only rays absorbed can be effective in producing chemical change. It is because silver bromide absorbs only blue-violet rays that it is insensitive to the rest of the spectrum.

If, however, the silver bromide be suitably coloured so as to absorb, say, green rays, it will then be affected by exposure to them. Eosin, erythrosin, pinaflavol and pinaverdol are capable of staining the grains of an emulsion and rendering it green-sensitive or *orthochromatic*. Other dyes, such as pinacyanol, will render the emulsion red-sensitive, and if a red-sensitizer be used in conjunction with a green-sensitizer, it can be made sensitive to the entire visible spectrum, or *panchromatic*, and its speed, especially to artificial light, very substantially increased.

To render orthochromatic the negative emulsion already described, one part of a 1 per cent. solution of erythrosin dissolved in equal parts of water and alcohol may be added to every 200 or 300 parts of emulsion, after digestion, but *before* the chrome alum and potassium bromide are added.

A panchromatic emulsion may be made by adding to each 200 or 300 parts of emulsion 2 to 3 parts of a 1 in 1000 solution in methyl alcohol of pinaverdol to the digested emulsion,

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which is then stood for about 15 minutes, and then adding a similar quantity of a 1 in 2000 solution of pinacyanol in methyl alcohol. The final additions are then made and the emulsion filtered. Needless to say, in the case of a panchromatic emulsion all additions must be made in green pan safelight or total darkness, and filtering and coating carried out in green light. Infra-red sensitive plates are made by similar additions to the emulsion of dicyanin or neocyanin solution, but a slower emulsion of extreme cleanness must be selected.

An emulsion having been made, we have now to consider its application to glass, or to film " base," or paper. Glass should be thoroughly cleaned with a stiff brush and a hot solution of sodium carbonate, or with a 4 per cent. solution of chromic acid, then very thoroughly rinsed and finally dipped in a solution of 5 grains of chrome alum to 1 ounce of water (1 per cent. solution). The glasses are placed in a clean rack, without rinsing, and dried. A levelling table will be required, such as a 15" × 12" piece of ¼ inch plate glass mounted on three screws or wedges and carefully levelled. The glass should be kept in a dish of ice water until wanted.

Some of the emulsion is filtered through a piece of plain lint into a clean glass measure, cooled to about 90° F. and a pool of it poured on to the centre of a glass, which is balanced on the fingers and thumb of one hand. The emulsion is coaxed by tilting it to first one corner and then the others in turn, and the excess poured off *into another measure*. About 4 c.c. (roughly one teaspoonful) will be required to coat a ¼ plate, larger sizes in proportion. This will give a " coating weight " of about 100–120 milligrams of silver to the square decimetre. Each coated plate is laid carefully on the cold levelling glass, and allowed about a minute to set. It can then be taken up and placed in a clean wooden rack, and the rack when filled put in a light-tight, dust-proof cupboard. The coated plates may be left to dry in darkness in the room if sufficiently free from dust. 5 or 6 hours at a temperature of 80–85° F. is best for drying, but if heat is not available the plates should dry easily overnight.

In commercial coating, glasses are placed on a travelling band, and passed under a spreading device which coats them with an even layer of emulsion. They then travel along an endless band or on running chains or cords, through a chilled " tunnel." On emerging, set, from the tunnel, an operator picks them up and racks them, and the racks are placed in

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drying cupboards supplied with washed air of a pre-determined temperature and humidity.

Films are usually coated on rolls of celluloid or cellulose acetate base 41 or 42 inches wide, the coated material being led over a large chilling drum and thence to a festooning arrangement where it travels slowly in the form of loops along an air-conditioned drying tunnel 300 ft. or more in length. The film, dry by the time it reaches the end of the run, is re-reeled ready for slitting and cutting.

Bromide papers are treated, after coating, with a second top coat of plain gelatin to prevent stress marks. When the emulsion is set, the band of paper is led through a second coating device and given the non-stress coating. It then passes over another cooling drum and thence to the festoon. Small sheets, such as 10 × 12 inch or 12 × 15 inch can be coated in the dark-room by floating paper for three minutes on the emulsion, which should be used at a temperature of 90°–100° F., in a dish kept warm by standing it in an outer dish of hot water. The sheets are pinned up to dry in the dark, and though the bottom of the sheet will be inevitably more thickly coated than the top, very good coatings can be made in this way for amateur work. See also BARYTA PAPER.

Unwashed Chloride Emulsion

The simplest formula for those wishing to experiment with emulsions, but not wanting to carry out the somewhat tedious process of washing, is for a silver chloride emulsion that can be used for making contact paper. A. Trumm gives a formula as follows:—

Water	20 oz.	(1000 c.c.)
Gelatin	790 gr.	(90 gm.)
Soaked for 1 hour, and then add:		
Sodium chloride (pure) ..	105 gr.	(12 gm.)

and heat on a water bath to 120° F. In the meantime make up a solution of:

Silver nitrate	½ oz.	(25 gm.)
Distilled water	2 oz.	(100 c.c.)

heat to 120° F., and add, a little at a time, to the gelatin-salt solution, stirring vigorously with a thick glass rod. The emulsion, after standing for half an hour, can be coated just as it is, but it will be slow and on the flat side. But by cooking

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it for 30 to 45 minutes on the water bath at 120° F. both speed and contrast will improve, and if coated on pure Whatman's or Rives' cartridge paper, or preferably on pure photographic base paper, will yield excellent contact prints. A little chrome alum solution should be added before filtering to toughen the film,—10 c.c. of a 5 per cent. solution would be advisable with the above quantity. An advantage of such an emulsion is that it can be made and coated in weak white light—all can be done 8 ft. from a 25 watt incandescent lamp.

See also COLLODION PROCESSES and COLOUR-SENSITIVE EMULSIONS.

Processes of emulsion-making are fully dealt with in *Photographic Emulsion Technique*, by T. Thorne Baker.

Enamel and Ceramic Photographs. Photographic images may be vitrified on porcelain and coated with a porcelain glaze, which makes them permanent as against fading. Enamels are usually prepared on small copper plaques, which are coated with a special material, which may practically be considered to be very soft milk-white glass, and by no means so unalterable as a true porcelain. On these an image is laid and fired. There are several processes—(*a*) the substitution process, (*b*) the powder process, (*c*) the pigment or carbon process, (*d*) the collotype process. For the substitution process a collodio-chloride printed-out positive is prepared and fixed. The image is toned with platinum, gold, palladium, iridium, or a selected mixture. The positive is then stripped, transferred to the plaque, and carefully smoothed out, and then fired, coated with glaze, and refired. The powder process is the preparation of a positive by the powder or dusting-on process on a sheet of glass, coating it with collodion, stripping, and transferring to the plaque, and firing. The pigment process is merely a modification of the carbon process, gum arabic instead of gelatine being sometimes used as the material; it is transferred and fired. The collotype process is sometimes used for preparing the image, a special ink being used and the print being on litho-transfer paper, from which it is transferred to the plaque. The collotype plate is inked with a fatty ink containing an ordinary underglaze pottery colour, and impression after impression is made on the unglazed tile; suitable precautions being taken to keep exact register. The tile is then fired and glazed like an ordinary piece of pottery. (See *Collotype* under PHOTO-MECHANICAL PRINTING PROCESSES.)

Standard books on this subject, long out of print, are

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Enamel Collodion

Photo-Ceramics, by Ethelbert Henry and Snowden Ward, and *Photographic Enamels*, by René d'Héliecourt.

Enamel Collodion. See ENAMELLING.

Enamelling. For securing a permanent high glaze on prints, enamel collodion was at one time used. It gave a practically waterproof glaze. The following formula is suitable :

Ether	4½ oz.	(110 c.c.)
Pure alcohol	3½ oz.	(85 c.c.)
Pyroxyline	30 gr.	(1·7 gm.)
Castor oil	24 drops	(1·4 c.c.)

Soak the pyroxyline in the alcohol, and then add the ether ; when dissolved add the castor oil ; allow to settle for several days, and then decant the clear solution. To apply the collodion, clean a plate of glass with French chalk, and coat with either of the foregoing mixtures according to the thickness required. As soon as it is set, slide the plate, face upward, into water in which the print is placed face downward. Lift the print and plate together to avoid airbells, squeegee, and set away to dry. When quite dry the print is peeled off the glass with the coating of highly glazed collodion adhering. (See also GLAZING PRINTS.)

Encaustic Paste. A paste used for imparting brilliancy to prints. The following formula may be used :—

Mix together white wax with Venice turpentine, the proportion of the former somewhat exceeding that of the latter, and dilute the mixture to a pasty consistency by means of spirits of turpentine. This is applied to the surface of the print by means of a soft flannel pad, by which a soft polish is communicated. Much shadow detail is thus brought out. (See also DOPE.)

Enlarged Negative, To make. See ENLARGING, also PAPER NEGATIVES.

Enlargements, To make. See ENLARGING.

Enlarging is the operation of obtaining on a sensitive surface a larger image of a negative or positive. Used without qualification the term is normally understood to mean the making of a print of dimensions greater than those of the negative it is made from. The method used is to illuminate the negative brightly and evenly. and then to use a lens to

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throw a sharp image of it to the required size on a piece of bromide paper or other suitable sensitive material.

It is evident that apparatus of very diverse kinds could be devised to fulfil these fundamental needs. For example, a quarter-plate negative might be placed against the window and photographed with a whole-plate camera the slide of

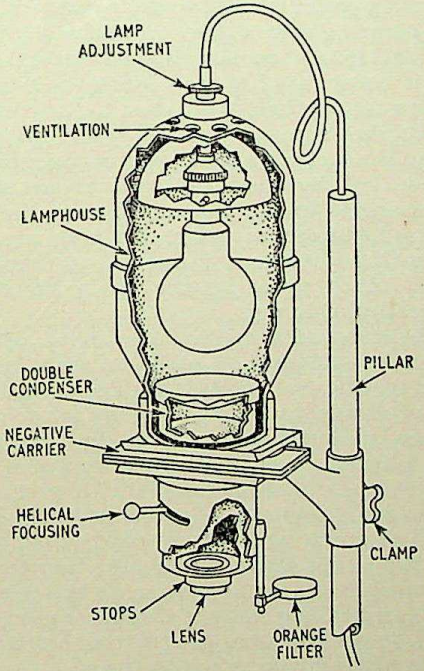

FIG. 1. Projection-head of a vertical enlarger.

which was loaded with a piece of bromide paper. Or an ordinary " magic lantern " could be used, putting the negative into the place normally occupied by the slide, and receiving the projected image on a piece of sensitive paper instead of on the usual insensitive white sheet.

The old type of horizontal enlarging lantern is, in fact, not very different in design from a " magic " or optical lantern,

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though it has certain adjustments and refinements that the lantern does not need. The vertical enlarger, which is the pattern now used by the majority of amateurs, is identical in principle, but it so made that the image is projected, not horizontally, but vertically downwards on to a baseboard.

The Vertical Enlarger.

The lantern, now more usually called the projector-head, is carried on an upright attached to the baseboard. To vary the size of enlargement it is moved up and down the upright as required. This form of construction has several advantages, of which one is economy of space, Further, it is easier to lay paper on a baseboard than to pin it on to the vertical surface of the easel or other support required when using a horizontal enlarger, and the fact that the upright is mounted on the baseboard ensures that the axis of the lens is always strictly vertical and at right-angles to the paper. Finally, the operations of adjusting size of image, focusing, changing negatives, and all the other small adjustments incidental to practical enlarging are rendered much easier by the ready accessibility of all parts of a vertical enlarger.

Electric light, usually in the form of an opal (not pearl) bulb, is almost universally used, a well-ventilated metal lamp-house serving to enclose all light. The negative, in some form of carrier providing for easy interchangeability of negatives, lies below the lamp. Even illumination is provided in the more inexpensive enlargers by means of diffusing screens of ground or opal glass between lamp and negative, but although the results obtained in this way can be completely satisfactory, so much light is wasted that exposures tend to be long. More expensive enlargers therefore employ a *condenser*, which is a lens or system of lenses so designed as to direct all light falling upon it through the negative and on towards the lens. By this means the illumination of the negative is made brilliant as well as even.

Below the negative is placed the lens, the function of which is to project a sharp image on to the paper on the base of the enlarger. A focusing movement of some kind is a necessary part of the enlarger, for even if the lens used is in a focusing mount, the range of movement is not sufficient for enlarging.

The Enlarger Lens.

It is sometimes thought that quite a cheap lens can be used in an enlarger. In one sense this is true; in another it is a most dangerous fallacy. It is the function of the enlarger lens

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to re-project on to the sensitive paper all the fine detail that the camera lens has recorded on the film; to do this, it has to be as well corrected, and as nearly perfect, as the camera lens itself. But—and here the cheapness comes in—it does not have to work at the wide aperture to which most modern camera lenses will open, and so can be of simple design. Generally an aperture of *f*/5·6 or even *f*/8 is quite wide enough for enlarging, though a wider aperture does make focusing easier. It is not safe, however, to focus at full aperture and stop down for exposing unless careful trial has shown that the focusing setting does not depend on the aperture in use.

If the camera lens is detachable, it should be tried in the enlarger before buying a special enlarging lens; at medium apertures most camera lenses, but not all, perform perfectly in an enlarger, though few can satisfactorily be used at their widest aperture.

Using the Enlarger. To make an enlargement, the negative is placed in the carrier and the projector-head raised or lowered till the projected image is of about the right size on the baseboard. It is then accurately focused. The action of focusing alters the size of the image somewhat, and it may be necessary to re-adjust the height of the head and re-focus. When the image is both sharp and of the right size, the light in the enlarger is switched off, and a piece of bromide paper is laid on the baseboard in the correct place to receive the image. The positioning of the paper may be controlled by using a masking frame (*q.v.*), by having on the baseboard a card marked out with rectangles of the standard sizes of bromide paper, or by other means. Alternatively, the light in the enlarger may be left on and a cap of orange glass put over the lens. This allows the projected image still to be seen, while cutting out all light to which the paper is sensitive; the image itself then serves as a guide when placing the paper. The cap, if used, is next removed, and the paper is exposed by switching on the light for the correct time. The paper is then removed and developed like any other bromide print. (See BROMIDE PAPER.) As in bromide printing, exposures are best determined by experiment with a small test-strip.

Automatic Focusing. Some more elaborate vertical enlargers are equipped with a mechanical linkage which moves the lens towards or away from the negative as the projector head is raised or lowered, thus keeping the image permanently in focus on the baseboard. To change the size of picture, all that is necessary is to raise or lower the head. The advantage

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conferred by this in speed and convenience is considerable, but it has no influence on the final result.

When adding a masking frame to an enlarger of this type, or dispensing with a frame for which the automatic focusing is adjusted, it is useful to know whether the decreased or increased distance between paper and lens will affect definition perceptibly. To determine this, multiply together the thickness of the masking frame and the focal length of the lens, and independently multiply the distance of the lens from the paper and the *f*-number of the stop to be used. Inches are to be used as the unit throughout. If the latter product is more than 100 times the former one, the loss in definition can be tolerated ; if it is more than 200 times as great, the loss in definition will be quite undetectable.

The diameter of the circle of confusion is given by the formula $c = fd \div nD$. The meanings of the symbols are evident from the above.

High Magnification. When it is required to make an unusually large print, or a print of normal size from a portion of the negative, it may be found that even with the projector head at the top of the upright the projected image is not large enough. Practically every manually-focused enlarger is so constructed that the projector-head can be turned round on the upright, when the projected image is no longer thrown on to the baseboard, but past it. The image is then received on a temporary support—*e.g.* a stool or chair—placed at a lower level than the baseboard. The arrangement is admittedly inconvenient, but serves well enough for occasional use. Attention is drawn to the fact that some enlargers equipped with automatic focusing cannot be used in this way.

The maximum magnification that can be obtained with the projector-head at the top of the column can be quickly estimated by measuring the distance from lens to baseboard. Divide this distance by the focal length of the lens, and subtract *one* from the answer. The result is the magnification obtained. (See MAGNIFICATION.)

It should be noted that at high magnifications the diffraction introduced by the use of a small stop may appreciably degrade definition; to avoid this the product of magnification and *f*-number should never be allowed to exceed 100.

Horizontal Enlargers.

With one or two exceptions, vertical enlargers for amateurs are only made for use with electric light. Where this is not

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available, it is in almost all cases necessary to use a horizontal enlarger, most models of which have a lamp-house roomy and well-ventilated enough to take illuminants such as incandescent gas, a spirit-vapour lamp, or acetylene.

In order that adequate ventilation may be ensured, the lamp-house of a horizontal enlarger generally has a large light-trapped cowl, and the back is often left open except for a black curtain. In front of the lamp-house, and joined to it by light-tight telescopic tubes or bellows, are the condenser and negative-carrier, mounted as one unit. The lens-panel comes in front of this again, with a rack-and-pinion focusing

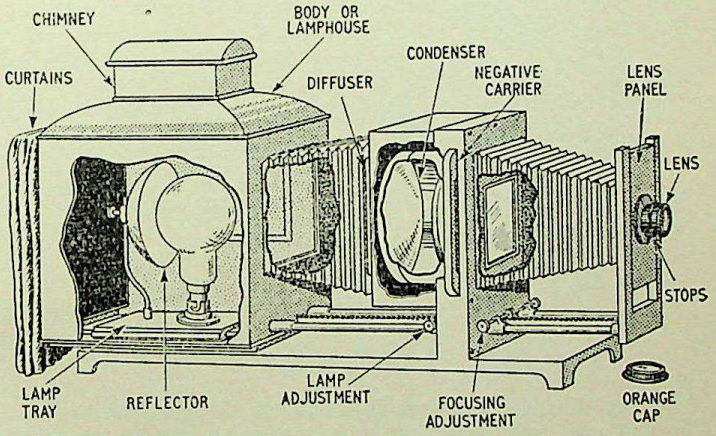

FIG. 2. Part cutaway view of a typical horizontal enlarger.

to vary the negative-to-lens distance. Bellows are used here again to keep in stray light.

One of the advantages of the horizontal enlarger is the opportunity it affords for the use of highly-concentrated light-sources such as the electric arc, a projection lamp, or a " Pointolite " enclosed tungsten arc. A powerful light such as this, sent through negative and projecting lens in a directed beam from a condenser, makes it possible to use slow paper, even when enlarging from a dense negative, without exposure being unduly prolonged.

Various types of easel have been devised for use in conjunction with a horizontal enlarger; all consist of a vertical

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board to which the paper is pinned, this being fitted with a heavy base to enable it to stand upright. In all but the cheapest models the easel folds backwards to allow the paper to be attached after focusing without risk of moving the base. If it is preferred not to deface the surface of the easel and the corners of the prints with pin-marks, the paper may be attached with surgical tape in the manner suggested in Fig. 3. See also JELLY FOR ENLARGING EASEL.

The Optical System of a Horizontal Enlarger.

The optical system of a horizontal enlarger is shown in the diagram of Fig. 4, from which it will be at once seen that

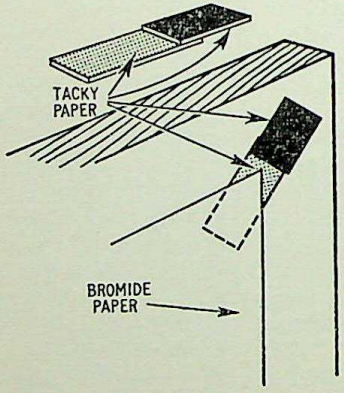

FIG. 3. Use of surgical tape for attaching the bromide paper to the easel. The paper is readily peeled off after exposure, and the tape may be moved to any part of the easel as required.

the duty of the condenser is to direct all light falling on it through the lens. In effect, this means that it forms at the lens an image of the light-source. If this image is formed elsewhere, light will be lost and the illumination will be uneven. Since the lens-to-negative distance has to be changed each time the enlarger is re-focused for a different magnification, the position of the light-source has each time to be readjusted so as to bring its image back on to the lens again.

In passing, an interesting type of design in which lamp-adjustment can be altogether avoided is worth noting. If the condenser is larger than the negative, lamp and lens can be left fixed at a position giving even illumination, focusing for different magnifications being carried out by moving the negative to and fro along the beam of light converging on the lens.

In the case of an enlarger of the ordinary design, it is evident

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that the adjustment of the whole system depends on the magnification (*q.v.*) in use. The ratio of the length of the projected image to that of the corresponding image on the negative is the same as the ratio of the distances Z and X. The exact values of these distances, which are called *conjugate foci* (*q.v.*) depend on the focal length of the lens in use. For a magnification of m diameters using a lens of focal length f they are :—

$$X = \frac{(m+1)}{m} f.$$
$$Z = (m+1) f.$$

The figures obtained for X and Z will be in the same units (inches, centimetres, or millimetres) that were used to express the focal length of the lens.

Values of X/f and Z/f are given for a number of different magnifications in the table on the next page ; by multiplying

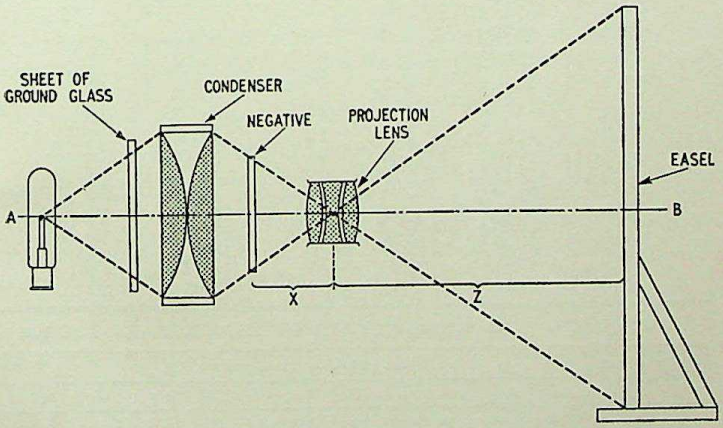

FIG. 4. Optical system of a horizontal enlarger.

the figures given for the magnification desired by the focal length of the lens in use, the distances X and Z can be found for any practical case. Ready-made figures for certain fixed values of magnification are given in the smaller table for lenses of the six most commonly-used focal lengths.

With the distance X determined, it at once becomes possible to work out the distance from the condenser at which the

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Table of Conjugate Foci

m.	X/*f.*	Z/*f.*	*m.*	X/*f.*	Z/*f.*
1·0	2·00	2·0	5·0	1·200	6·0
1·1	1·909	2·1	5·2	1·192	6·2
1·2	1·835	2·2	5·4	1·185	6·4
1·3	1·769	2·3	5·6	1·179	6·6
1·4	1·715	2·4	5·8	1·172	6·8
1·5	1·667	2·5	6·0	1·167	7·0
1·6	1·625	2·6	6·2	1·161	7·2
1·7	1·588	2·7	6·4	1·156	7·4
1·8	1·557	2·8	6·6	1·152	7·6
1·9	1·526	2·9	6·8	1·147	7·8
2·0	1·500	3·0	7·0	1·143	8·0
2·2	1·455	3·2	7·5	1·333	8·5
2·4	1·417	3·4	8·0	1·125	9·0
2·6	1·384	3·6	8·5	1·118	9·5
2·8	1·357	3·8	9·0	1·111	10
3·0	1·333	4·0	9·5	1·105	10·5
3·2	1·312	4·2	10·0	1·100	11
3·4	1·284	4·4	11	1·091	12
3·6	1·278	4·6	12	1·083	13
3·8	1·264	4·8	13	1·077	14
4·0	1·250	5·0	14	1·072	15
4·2	1·238	5·2	15	1·067	16
4·4	1·228	5·4	16	1·063	17
4·6	1·218	5·6	18	1·056	19
4·8	1·208	5·8	20	1·050	21

Lens-Paper and Lens-Negative Distances in Inches

Focal Length of Lens.	Magnification in Diameters.										
	1	2	3	4	5	6	8	10	12	15	20
3·5 cm. (1·38 in.)	2·76 2·76	4·14 2·07	5·51 1·84	6·90 1·72	8·27 1·65	9·65 1·61	12·4 1·55	15·1 1·51	17·9 1·49	22·0 1·47	28·9 1·45
5·0 cm. (1·97 in.)	3·94 3·94	5·90 2·95	7·87 2·62	9·85 2·46	11·8 2·36	13·8 2·30	17·7 2·21	21·6 2·16	25·6 2·13	31·5 2·10	41·4 2·07
7·5 cm.) (2·95 in.)	5·90 5·90	8·85 4·42	11·8 3·94	14·75 3·69	17·7 3·54	20·6 3·43	26·6 3·32	32·5 3·25	38·4 3·20	47·2 3·15	62·0 3·10
10·5 cm. (4.14 in.)	8·26 8·26	12·4 6·20	16·5 5·50	20·7 5·17	24·8 4·96	29·0 4·84	37·2 4·65	45·5 4·55	53·7 4·48	66·1 4·41	86·9 4·35
13·5 cm. (5.31 in.)	10·6 10·6	15·9 7·95	21·2 7·07	26·6 6·65	31·9 6·38	37·2 6·20	47·9 5·98	58·5 5·85	69·0 5·75	85·0 5·66	111·5 5·58
15·0 cm. (5·90 in.)	11·8 11·8	17·7 8·85	23·6 7·86	29·6 7·40	35·4 7·08	41·4 6·90	53·1 6·64	65·0 6·50	76·8 6·40	94·5 6·30	124·0 6·20

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light must be placed to ensure that the whole of the light passes through the lens.

The distance from the node (*q.v.*) of the condenser to the lens is the sum of X and the distance of the negative from the node of the condenser. Calling the sum of these two distances D, then if the focal length of the condenser is F, the distance of the light source from the other node of the condenser will have to be $\frac{D\,F}{D - F}$.

Example. We are enlarging a quarter-plate negative to whole-plate, using a lens of focal length $5\frac{1}{2}$ in. The focal length of the condenser is 5 in., and the negative is 3 in. from one node. What are the distances X and Z, and how far should the light be from the condenser ?

Enlarging $4\frac{1}{4} \times 3\frac{1}{4}$ to $8\frac{1}{2} \times 6\frac{1}{2}$ is two diameters. Under $m = 2$, we find $Z/f = 3{\cdot}0$ and $X/f = 1{\cdot}5$. The lens-paper distance Z will therefore be $3 \times 5\frac{1}{2} = 16\frac{1}{2}$ in. and the lens-negative distance X will be $1{\cdot}5 \times 5\frac{1}{2} = 8\frac{1}{4}$ in. The distance D from lens to condenser will be 3 in. more than X, or $11\frac{1}{4}$ in. From the last formula, the lamp-condenser distance will have to be $\frac{11\frac{1}{4} \times 5}{11\frac{1}{4} - 5} = \frac{56\frac{1}{4}}{6\frac{1}{4}} = 9$ in. from the other node.

These two fundamental formulæ are useful when the focal length of lens and condenser are known, but are not very readily applicable, as they stand, to the design of the optical system of an enlarger. Although design formulæ of various kinds can be calculated, their precise form depends on the conditions that have to be fulfilled.

The choice of the lens is a simple matter ; all that is needed is that it should be capable of covering the negative to be enlarged from. It should of course, be an anastigmat, and its focal length may conveniently be about equal to the diagonal of the negative. The lens from the camera, if detachable, will in most cases be found perfectly suitable.

It is now universally considered desirable that the lens used in an enlarger should be treated to prevent internal reflections. (See Coated Lenses.) The effect of this is to reduce the amount of stray light scattered into the darker parts of the projected image, thus giving a print of improved quality and tonal gradations in the highlights. The extent of the improvement brought about by using a coated lens depends a good deal on the character of the negative ; if this is soft and has much the same density in all parts (*e.g.*, an open landscape

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subject) the improvement is small. But with a negative having both some fairly dense areas and some areas of nearly complete transparency (*e.g.*, a portrait taken against a black background) the improvement is usually very marked indeed. To obtain the full benefit of the elimination of lens-reflections, other possible sources of scattered light should also be eliminated. Special attention should be paid to the prevention of reflections from the sides of the focusing tube, bellows, etc., that lie between lens and negative.

It is usually convenient to have the light as far away from the condenser on one side as the lens is on the other, so that the condenser is at the centre of the optical system. With the usual type of condenser, this arrangement has the further advantage that aberrations in the condenser are then at a minimum. The lens-negative distances for the largest and smallest magnifications likely to be required can be found as above ; if the mean of these is taken and the proposed condenser-to-negative distance is added, half the result gives a convenient focal length for the condenser. With the lens in its mean position, the light will then have to be at a distance from the condenser equal to twice its focal length. If the light is sufficiently diffused, it may not need to be moved for various magnifications, in which case the position just mentioned will be the most favourable to even illumination at different magnifications ; with an undiffused or slightly diffused source of light some movement either way must be allowed for. Once the focal length of the condenser is settled, the formula above will enable the required range of movement to be found.

By choosing a condenser of rather shorter focal length than that found by the above means, the light-efficiency will be increased, resulting in shorter exposures, and the range of movement required for the light will be decreased. Greater accuracy in positioning the light will, however, be required, and the lamp will have to be brought a good deal nearer the condenser, as application of the formula above will show. Care must be taken not to bring it too near, or there may be danger of cracking the condenser-lenses. It must throughout be remembered that calculated lamp-condenser or negative-condenser distances are not to be measured from the surface of the condenser, but from its nodes. In most cases a close enough approximation to this is had by regarding the distances worked out as to be measured from the centre-line of the condenser—i.e. from half-way through its thickness.

The ability to work out these distances in the way shown

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is essential in any case where an attempt is made to design an enlarger and assemble it from bought parts, but in practice the final adjustments are always made by trial and error. After the image has been focused to the required size, the negative is withdrawn from the carrier and the light moved until the disc of light on the easel is of even brightness. A disc brighter at the top than at the bottom means that the light is too low ; in general, the light requires to be moved up and down, or from side to side, towards the more brilliantly illuminated side of the projected disc.

By this means the light is manœuvred on to the axis of the optical system, but still the illumination will only be even if the condenser-lamp distance is correct. If the disc is brighter at the centre than at the edges, the lamp is too far from the condenser ; if it is darker at the centre, it is too near. When the adjustment of the lamp is finally correct, the negative may be returned to the carrier and the enlargement made.

Unless the very maximum of light is wanted, it is usual to dispense with the need for all this adjustment by diffusing the light to some extent. This blurs, and so enlarges, the image of the light-source thrown by the condenser to an extent sufficient to make it possible to cover, by a single adjustment of the light, the range of magnifications usually needed in practice. Diffusion may be introduced either by placing one or more sheets of ground glass in the position indicated in Fig. 4, or by replacing the point source of light by one of large dimensions such as an opal bulb. It is by adopting this latter illuminant that the vertical enlarger described earlier is enabled to dispense with any need for adjusting the position of the light.

Condenser versus Diffuser.

As the light in a condenser enlarger is directed towards the lens, any light scattered out of its original path in passing through a particular point of the negative will fail to reach the image. This loss of light is additional to any loss due to absorption of light by the negative at the point considered. In an enlarger using diffused light, absorption by the negative is the only factor concerned ; the projected image is therefore less contrasty. An enlargement made with diffused light has the same contrast as a direct contact print on the same grade of paper.

The increase of contrast due to scattering when enlarging by directed light is called the Callier effect, after the first

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investigator of the phenomenon. It is quite large in some cases; recorded measurements on one particular negative gave a contrast-range (ratio of extreme opacities) of 32 to 1 by diffused light, rising to 570 to 1 by the directed light of a condenser enlarger with a point source and no diffusion. It is quite usual to find that the use of directed light doubles the contrast range; the increase will obviously depend largely on the character and density of the silver deposit in the negative, as well as upon the amount of diffusion, intentional or otherwise, in the lighting system.

When using fully directed light any scratch or surface-marking on the negative, including the pencil-marks of retouching and the limits of the area covered with retouching medium, show up very clearly indeed on account of the light that all such surface irregularities must scatter; graininess is enhanced for the same reason. It is to avoid the emphasizing of these accidental defects that fully directed light is now practically never used.

It is often asserted that a condenser enlarger gives sharper definition than one using a diffuser; this is not the case, as the sole function of either is to illuminate the negative evenly and brightly. The sharpness of the enlarged print depends entirely on the lens and its adjustment. It is the increased contrast given by the condenser enlarger that is often mistaken for increased sharpness.

Diffusing Systems.

A small negative can be illuminated sufficiently evenly simply by placing close behind it an opal bulb of large size. For larger negatives a diffuser, consisting of a sheet of opal glass, is usually interposed between lamp and negative. It should be noted that the diffuser must be of larger size than the negative in order that it may be "seen" behind the margins of the negative from the point of view of the lens. (Compare Fig. 4, where the condenser is shown as rather larger than the negative for the same reason.)

Generally it is necessary to use several lamps to ensure even illumination of the diffuser; similar results, however, may be obtained by means of a single lamp and a series of mirror reflectors suitably disposed. Extra diffusion may also be had by using two opal glasses, spaced apart by about an inch, in place of one.

Often there is an excess of light in the centre of the projected image, at a point corresponding to the direct line joining

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lens and lamp. To darken this patch to the level of the rest of the field, the tip of the lamp may be obscured. If two diffusers are used, that nearest the lamp may have discs of a semi-transparent material such as tracing paper cemented to it. A single disc may suffice, or a small pile of discs of graduated diameters, the largest being applied first and the smallest last, may be found more effective. Or ground-glass may be used for the first diffuser, this being varnished round the edges to increase its transparency, and darkened with pencil at the centre.

Mercury-Vapour Lamps. The mercury-vapour lamp, which consists of a glass tube through which passes an arc between mercury electrodes, is widely used in trade houses and professional dark-rooms. The tube is generally bent into the form of a "W," thus presenting so large a radiating surface that but little diffusion is needed to get even illumination. It is particularly suitable for use with comparatively large negatives. and has the advantage that as it consumes little current it gives but little heat. But with some chlorobromide papers, including such papers as Plastika and Multigrade, the mercury-vapour lamp may be found to give very flat prints.

Constructional Details and Accessories.

Viewed from the position of the lens, the condenser in a correctly-adjusted enlarger appears brilliantly luminous over its whole surface. It acts, in effect, as a large light-source immediately behind the negative, from which it is evident that it must have a diameter not less than the diagonal of the negative. In practice a slightly greater diameter is desirable, because the negative is placed in the beam of light at a point where it is converging towards the lens.

To combine the necessary short focal length with the large diameter required, a condenser is generally made up of two plano-convex lenses, mounted in a cell with their curved surfaces inwards and practically in contact. Such a combination is sometimes called a "double condenser." (See CONDENSER.)

With a horizontal enlarger a support for the paper is required. Though the wall may be used, this involves moving the enlarger bodily when the degree of magnification is changed, and it is therefore more convenient to provide an easel for the paper. This consists simply of a vertical board, framed to prevent warping, and mounted on a suitable foot or base. In a permanent installation, the easel may be

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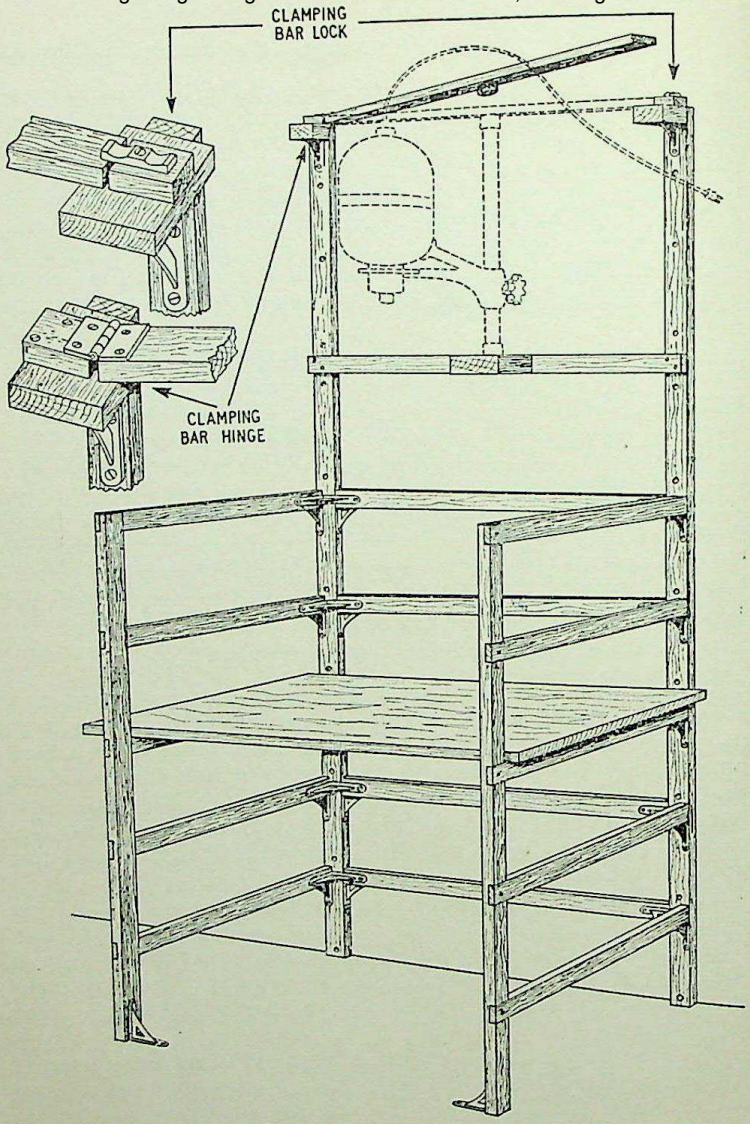

FIG. 5. Suggested stand for a vertical enlarger. Upright and head are instantly detachable for storage, and the movable baseboard allows for any degree of enlargement. Successive runners should be spaced by a distance just less than the range of movement of the head on the upright. Rigid construction is essential. 2 x 1 in. wood, re-inforced with stout angle brackets, is suitable. The whole is screwed to wall and floor as indicated.

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mounted so as to slide along a horizontal bed to which the enlarger is also attached, thus ensuring that the paper is always at right angles to the axis of the lens.

With a horizontal enlarger the degree of enlargement obtainable is limited only by the size of the room used, or by the length of the bed along which the easel runs. Where large prints are likely to be wanted frequently from a vertical enlarger the upright may be detached from the base and attached by brackets to the wall. A movable shelf, sliding on to a series of supports spaced apart by a distance a little less than the range of movement of the head on the upright, may be fitted below it to take the paper. Such an erection allows the full distance from top of upright to floor, or any desired part of this distance, to be used without the need for any makeshift supports. The accompanying sketch (Fig. 5) will make clearer the kind of construction envisaged.

Focusing the projected image is sometimes difficult, especially when the negative is dense or the magnification considerable. A simple magnifier is usually not very helpful as if powerful enough to be of value it, and the user's head, come between lens and image, so cutting off the light. A focusing negative (dense black with a pattern of clear lines, fogged film or plate with scratches cut through emulsion) is serviceable as providing something clear, bright, and definite to focus on ; but with an insufficiently accurately made enlarger these may be little guarantee that the negative to be enlarged, when substituted for the focusing negative, will occupy the same plane with sufficient precision. This point should be most carefully checked before deciding to rely on a focusing negative.

A reflex focusing magnifier is in most cases preferable. It consists of a mirror, placed at an angle, that reflects light from the lens on to a ground glass screen which is viewed through a magnifier. The design must be such that the distance from lens to screen, *via* the mirror, is equal to that from lens to the baseboard on which the device stands. To be serviceable, the focusing screen must be of very finely ground glass. The chief virtue of these reflex focusers is that the visual brilliance of the projected image is greatly enhanced.

As the lens and focusing movement of an enlarger are practically identical with those of a camera, any camera with rack-and-pinion focusing can be converted into an enlarger by fitting a lamp-house to it. The modern self-erecting camera with fixed extension is less easily adapted, as the

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focusing has too little range of movement. Experiment with the open camera will soon show the possibilities of any individual instrument, but the adaptation is in most cases best made by arranging a series of grooves or runners to provide alternative positions for the negative carrier. The grooves should be spaced apart at a distance a little less than the available focusing movement of the lens.

Fixed-Focus and Daylight Enlargers.

Fixed-Focus Enlargers. A fixed-focus enlarger generally consists of a box with a dark-slide for the bromide paper at one end and a negative carrier at the other. A lens is fixed between the two on a septum so placed as to give sharp focus (see table of conjugate foci on p. 271). Most such enlargers are intended for use with daylight, and so have no lamp-house. Owing to the brilliance of daylight, a cheap single lens, well stopped down (about *f*/22 to *f*/32), is fast enough to give reasonably short exposures, and at such a small stop gives very acceptable definition.

Enlarging by Daylight. If a room is darkened by means of a shutter blocking up the window, a hole to take the back of a camera may be made in the shutter. With a window facing north, and a camera with adequate focusing movement, perfectly satisfactory enlargements can be made at all times of day. Even illumination can be secured by using sky light reflected from a white card placed outside the window at an angle of 45°. Owing to its variability, daylight is not a very satisfactory illuminant. With the arrangement described, or with a fixed-focus enlarger used by daylight, it is desirable to use some type of exposure meter (*q.v.*) to control exposures.

Determining Exposures when Enlarging.

Various methods of determining exposure in enlarging have been suggested, but most depend on estimating, by photo-cell meter or otherwise, the total amount of light passing the enlarger lens. Such methods can never be more than a rough guide, as they ignore the proportion of light to shade on the negative. Sufficient accuracy is only obtainable by making independent measurements of the brightness of high-light and shadow in the projected image. Several photo-meters, of grease-spot type, have been designed for this work, the brightness of the image being compared with that of an auxiliary lamp controlled by resistance or (better) by distance

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from the grease-spot. These measurements, used in conjunction with previous determinations of the exposure necessary to give (*a*) lightest perceptible grey and (*b*) a practically full black on the paper to be used, enable exact choice of paper-contrast to be made and accurate exposure to be given.

Shading and Double Printing.

A straight enlargement made from a negative without modification may be good, but in a very large number of cases improvements can be made by giving one or other part of the picture more or less exposure than the rest. Even without a filter, clouds, if any were present when the photograph was taken, are generally recorded on the negative, but in a majority of cases the sky as a whole prints too light for them to have their full effect.

A possible remedy for this is the use of a soft paper, but this usually flattens contrasts to an undesirable extent. It is almost always preferable to use the grade of paper suited to the subject as a whole, and to bring up the sky by extra printing. Separate test-strips, one for the landscape and one for the sky, will show what exposure each needs. That for the sky is usually rather less than double the exposure needed for the landscape.

The print is then given the shorter of the two exposures, after which the landscape is protected, by a piece of paper or card held between lens and sensitive paper, until the exposure for the sky is completed. If the skyline is simple, the straight edge of the paper will suffice as a mask. Held above the print, its shadow will be blurred so that no sharp line of demarcation between shaded and unshaded area will show. Diffusion of the edge can be further enhanced by moving it about a little during exposure.

For a more elaborate outline, if it cannot be matched nearly enough by simpler means, a mask may be cut. Support a piece of black or brown paper about 5 in. above the baseboard, and mark the skyline out on it in pencil. The image will be blurred, of course, but not so much so as to make it difficult to follow the outline. The mask is cut out, and though smaller than the image, its shadow will be a good fit on it if held at the height at which it was made.

Small areas can be darkened by cutting out from a piece of white paper a hole of the same shape as the area to be darkened, but smaller. The blurred image on the white paper mask serves as a guide when giving the extra exposure. If it is

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desired to decrease rather than accentuate the contrast in the highlights, it is often better to remove the negative from the carrier before giving this extra local exposure.

Lightening small areas can be done by means of a piece of card, or a tuft of cotton-wool, impaled on a wire. If the latter is moved during the exposure its shadow will not show.

Clouds can be printed in, and other simple combination printing carried out, by similar means. The mask is cut as before, but both parts are kept. First the mask that covers the sky is used, fixing it in place some 5 in. above the print and exposing through the landscape negative. Next the other half of the mask is brought up to the first, fitted to it, and pinned in place, after which the first half of the mask is taken away and the exposure for the clouds is made.

These notes are but suggestions; the variations and developments possible are endless.

Simultaneous Exposure and Development.

A method of developing bromide paper during the exposure so that exposure actually depends upon the completion of development, has been suggested by F. J. Mortimer.

The image is first focused on the easel as usual, but in this case the surface of the board is covered with white American cloth or white opal. The yellow glass cap is placed on the lens, and the bromide paper is soaked in developer for 2 minutes and then applied in the correct position to the enlarging easel. It will stick to the surface without further attention. The lens is then uncapped, and the exposure and development will proceed automatically together. If the negative is dense, or the exposure otherwise prolonged, fresh developer can be gently brushed on to the wet surface of the print from time to time with a camel-hair mop.

The progress of development is observed by covering the lens for a second or two with a piece of ground glass (ground yellow glass is best). When development is complete the print is simply stripped off and placed in the fixing bath.

It is to be noted that in this process the shadows, developing up comparatively early during the exposure, act as a kind of mask to check further exposure in the shadow areas. The gradation of a print exposed and developed together is therefore not the same as that of a print normally made. The extent to which the gradation is altered evidently depends on the relative rates of the two processes, and will therefore be controlled by temperature, the composition of the developer,

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the brilliance of the light in the enlarger, the stop used, and the degree of enlargement.

Much fuller control over the gradation of the print can be had by giving part of the total exposure required, developing to finality, completing the exposure, and developing again. This can be done by the method described, provided that the duration of the first part of the exposure is shorter than the time of appearance of the image. If this is not the case the paper may be exposed wet with water, sponged over with developer after the first exposure, and then, when development is complete, exposed further. To ensure registration it must of course remain on the easel or baseboard throughout. With a vertical enlarger the paper may be laid in a dish.

If the paper in use shows a tendency to fog or stain as a result of the prolonged exposure to air while wet with developer, the following developer should be tried :—

Potassium metabisulphite .	790 gr.	(45 gm.)
Caustic potash . . .	790 gr.	(45 gm.)
Glycin	525 gr.	(30 gm.)
Water to make . .	10 oz.	(250 c.c.)

This may be diluted as required ; normal dilution is 1 part to 10 parts of water and a developer-improver (*q.v.*) should be added. If fog or stain are still encountered, reduce the metabisulphite to 22·5 gm. (395 gr.) and the caustic potash to 34 gm. (600 gr.)

Making Enlarged Negatives.

For certain printing processes requiring daylight, or when a negative is too small to retouch, an enlarged negative may be made. For economy in material, the negative may be made by reversal, but most amateurs will probably prefer either to make a contact transparency and then enlarge from that to obtain the negative, or to make an enlarged positive from which the negative can be made by contact. The familiar processes of negative-making are here used throughout. The intermediate positive should have the characteristics of a negative so far as density and contrast are concerned ; that is, it should be much too dark when looked at as it lies in the dish, but should appear satisfactory when viewed by transmitted light. For both transparency and enlarged negative a slow plate or film should be used. During exposure under

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the enlarger, a piece of black paper should be placed between the plate or film and the easel to prevent reflection.

The enlarged positive is to be preferred to the contact positive in cases where the enlarging is being done to facilitate retouching, as in this case both positive and negative can be retouched if desired. In other cases neither method offers any appreciable advantage over the other.

Enlarging Easel. See ENLARGING, and JELLY FOR ENLARGING EASEL.

Enprint. Name given to a small enlargement, usually on paper 3½ in. wide, and of length to accommodate the length of the negative, made from the whole of a negative. They are supplied by all D. & P. firms at little more than contact-print prices.

Episcope ; Epidiascope. The episcope is an apparatus for projecting on to a lantern-screen images of opaque objects such as paper prints, postcards, coins, or medals. The principle is that of the ordinary projection lantern, except that the object to be projected, not being transparent, has to be illuminated from in front instead of from behind. Owing to the fact that a condenser cannot be used, the image is not brilliant unless the amount of light used is considerable. The projected image is reversed from right to left unless steps are taken to re-reverse it ; this is usually done by interposing a mirror or a reflecting prism at some point in the optical path.

An epidiascope is simply an episcope that is equipped for projecting ordinary slides as well as opaque objects.

Equivalence, Chemical ; Calculations and Data. A chemist would define the equivalent weight of a substance as that weight of it which will combine with, or replace, one gram of hydrogen. The idea of equivalence, as between similar substances, is based on this definition. To take an example, 35·5 gm. of chlorine combine with 1 gm. of hydrogen to form hydrochloric acid, and 80 gm. of bromine combine with 1 gm. of hydrogen to form hydrobromic acid; 35·5 gm. of chlorine are therefore said to be equivalent to 80 gm. of bromine, on the grounds that the substances are interchangeable in these proportions. It is of the greatest importance to note that equivalence in any one connection—in this case, in combining with hydrogen—implies equivalence (or interchangeability) in every other direction too. It follows that when any two substances combine together or

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react with one another, they do so in the proportions of their equivalent weights.

Nevertheless, no short instructions or tabulations of data can be sufficiently detailed to make anyone without a chemical training quite safe in determining equivalent quantities, for there are many cases where the equivalent weight of a substance may have different values according to the type of chemical reaction which it is undergoing. In combining with an acid, iron may have an equivalent weight of 28 (making a ferrous salt) or 18·7 (making a ferric salt), while when we consider the change from the ferrous to the ferric state, or

TABLE I. THE MORE IMPORTANT ELEMENTS AND THEIR ATOMIC WEIGHT

Name	Symbol	Atomic weight
Aluminium	Al	27
Antimony	Sb (Stibium)	122
Arsenic	As	75
Barium	Ba	137
Bismuth	Bi	209
Boron	B	11
Bromine	Br	80
Cadmium	Cd	112
Cæsium	Cs	133
Calcium	Ca	40
Carbon	C	12
Cerium	Ce	140
Chlorine	Cl	35·5
Chromium	Cr	52
Cobalt	Co	59
Copper	Cu (Cuprum)	63
Fluorine	F	19
Gold	Au (Aurum)	197
Helium	He	4
Hydrogen	H	1
Iodine	I	127
Iron	Fe (Ferrum)	56
Lead	Pb (Plumbum)	207
Lithium	Li	7
Magnesium	Mg	24
Manganese	Mn	55
Mercury	Hg (Hydrargyrum)	200

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TABLE I. (*Continued*) THE MORE IMPORTANT ELEMENTS AND THEIR ATOMIC WEIGHT

Name	Symbol	Atomic weight
Molybdenum	Mo	96
Nickel	Ni	59
Nitrogen	N	14
Osmium	Os	190
Oxygen	O	16
Palladium	Pd	106
Phosphorus	P	31
Platinum	Pt	195
Potassium	K (Kalium)	39
Rubidium	Rb	85
Selenium	Se	79
Silicon	Si	28
Silver	Ag (Argentum)	108
Sodium	Na (Natrium)	23
Strontium	Sr	88
Sulphur	S	32
Tantalum	Ta	181
Tellurium	Te	128
Thallium	Tl	204
Tin	Sn (Stannum)	119
Titanium	Ti	48
Tungsten	W (Wolfram)	184
Uranium	U	238
Vanadium	V	51
Zinc	Zn	65
Zirconium	Zr	91

vice versa, its equivalent is 56. Examples such as these could be multiplied considerably, but this one will serve as a warning that the layman needs to draw his conclusions with some reserve.

The observant will have noticed that the figures just given are related ; they are 56, 56/2, and 56/3. This simple relationship between the different equivalent weights that one substance can have arises from the fact that chemical reactions take place between atoms. The atom of iron is 56 times as heavy as that of hydrogen ; when iron displays an equivalent weight of 56 each atom of it is reacting with one atom of hydrogen (or its equivalent of some other substance). When

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the equivalent weight is 56/2, or 28, each atom of iron is reacting with two of hydrogen ; when it is 56/3, with three.

The ratio of the weight of an atom of an element to that of an atom of hydrogen is called the atomic weight of the element, and its equivalent weight is always related to the atomic weight in some simple manner, as in the case of iron just discussed. Table 1 gives the atomic weights of the more common elements with an accuracy sufficient for all ordinary photographic purposes.

Chemical Formulæ.

With a few exceptions, notably the metals, compounds are much more commonly met with than are elements. A compound consists of a combination of two or more elements, and since a compound can only be built up by combinations of whole numbers of atoms, its composition can be—and usually is—expressed by means of the symbols given in the above table. Silver chloride is built up, as analysis can readily show, from 108 gm. of silver to every 35·5 gm. of chlorine. That is, it consists of one atom of chlorine to each atom of silver. Its formula is consequently written AgCl, which formula, it is to be observed, implies the quantitative relationship just given. The " compound atom " (one atom of each element), which is the smallest unit of silver chloride, is known as a *molecule*, and the molecular weight is the sum of the weights of the atoms involved—in this case 108 + 35·5 or 143·5. Just as an element enters into chemical reaction in units of not less than one atom, a compound enters in units of not less than one molecule.

More complicated formulæ are similarly constructed by writing in juxtaposition the symbols for the elements involved ; silver nitrate is written $AgNO_3$, which means that it is built up of one silver, one nitrogen, and three oxygen atoms. Taken in conjunction with the atomic weights, the formula again gives the composition, by weight, of the substance. Note that the small subscript " 3 " applies only to the oxygen. To make it apply to symbols other than that immediately preceding it, brackets are introduced. Slaked lime, or calcium hydroxide, is represented as $Ca(OH)_2$, meaning that two " hydroxyl " (OH) groups are attached to each calcium atom. The group itself may contain subscript figures, as in calcium nitrate, $Ca(NO_3)_2$, where two " nitrate " (NO_3) groups are attached to the calcium atom in place of the hydroxyl groups. These subscript figures are only used when it is an atom, or a

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group incapable of separate existence, that is to be shown as present more than once in the formula ; where, as in the case of a double salt or a compound containing water of crystallisation, it is a complete molecule that is to be " multiplied," a full-size figure *precedes* the formula of the molecule in question. Crystalline sodium carbonate, for example, has the formula $Na_2CO_3 10H_2O$; to form the crystals ten molecules of water combine with each molecule of the anhydrous carbonate Na_2CO_3.

The formula is all that is needed to determine the equivalence between anhydrous and crystalline carbonate. The molecular weight of Na_2CO_3 is $23+23+12+16+16+16=46+12+48=106$. That of water is $1+1+16=18$, so that in the crystals 180 gm. of water are combined with each 106 gm. of carbonate to make a total of 286 gm. Every 286 gm. of crystalline sodium carbonate therefore contains 106 gm. of the anhydrous carbonate ; if the latter is to be used in making up a developer the formula for which calls for crystals, 106 gm. of the anhydrous salt may be used for every 286 gm. of crystals prescribed. A similar analysis will show that the corresponding figures for anhydrous and crystalline sodium sulphite (formula of the latter $Na_2SO_3 7H_2O$) are 126 and 252 ; by a coincidence extremely convenient for photographers, these are precisely in the ratio of two to one.

Chemical Equations.

A chemical equation shows, by means of the formulæ, what happens in a chemical reaction. Mixing a solution of silver nitrate with one of potassium bromide results in the formation of insoluble silver bromide and potassium nitrate, thus :—

$$AgNO_3 + KBr = AgBr + KNO_3$$

Since one molecule of each substance is involved, we know that 119 gm. of KBr react exactly with 170 gm. of $AgNO_3$, leaving no unused excess of either. 188 gm. of AgBr and 101 gm. of KNO_3 are formed. An equation of this type can be formulated for any reaction the course of which is known.

Table II gives the formula of most of the commoner substances used in photographic work, together with the molecular weight of each. Where water of crystallisation is shown, it is included in the molecular weight.

Reference may also be made to the following articles:— Calculations and Constants, Thermometry, Weights and Measures, also Solutions and Solubility.

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TABLE II. FORMULÆ

	Formula	Molecular Weight
Acetic acid	CH_3COOH	60
Alcohol (ethyl)	C_2H_5OH	46
Alum (ordinary)	$Al_2(SO_4)_3K_2SO_424H_2O$	948
Ammonia	NH_3	17
Ammonium bichromate	$(NH_4)_2Cr_2O_7$	252
Ammonium bromide	NH_4Br	98
Ammonium carbonate (normal)	$(NH_4)_2CO_3H_2O$	114
Ammonium chloride	NH_4Cl	53·5
Ammonium hydrosulphide	NH_4HS	51
Ammonium hydroxide	NH_4OH	35
Ammonium iodide	NH_4I	145
Ammonium nitrate	NH_4NO_3	80
Ammonium oxalate	$(NH_4)_2C_2O_4H_2O$	142
Ammonium persulphate	$(NH_4)_2S_2O_8$	228
Ammonium sulphate	$(NH_4)_2SO_4$	132
Ammonium thiocyanate	NH_4CNS	76
Barium bromide	$BaBr_22H_2O$	333
Barium carbonate	$BaCO_3$	197
Barium chloride	$BaCl_22H_2O$	244
Barium hydroxide	$Ba(OH)_28H_2O$	315
Barium iodide	BaI_22H_2O	427
Barium nitrate	$Ba(NO_3)_2$	261
Barium sulphide	BaS	169
Borax	$Na_2B_4O_710H_2O$	382
Boric acid	H_2BO_3	62
Cadmium bromide	$CdBr_24H_2O$	344
Cadmium chloride	$CdCl_22\frac{1}{2}H_2O$	228
Cadmium iodide	CdI_2	366
Calcium bromide	$CaBr_26H_2O$	308
Calcium carbide	CaC_2	64
Calcium carbonate	$CaCO_3$	100
Calcium chloride	$CaCl_26H_2O$	219
Calcium hydroxide (slaked lime)	$Ca(OH)_2$	74
Calcium iodide	CaI_26H_2O	402
Calcium oxide (quicklime)	CaO	56
Carbolic acid (phenol)	C_6H_5OH	94
Chrome alum	$Cr_2(SO_4)_3K_2SO_424H_2O$	999
Citric acid	$C_3H_4(OH)(COOH)_3H_2O$	210
Copper acetate	$Cu(C_2H_3O_2)_2H_2O$	200
Copper bromide	$CuBr_2$	223
Copper chloride	$CuCl_22H_2O$	171
Copper nitrate	$Cu(NO_3)_23H_2O$	242
Copper sulphate	$CuSO_45H_2O$	250

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TABLE II (*Continued*). FORMULÆ

	Formula	Molecular Weight
Ferric chloride	$FeCl_3$	162
Ferric citrate	$FeC_6H_5O_7$	245
Ferric oxalate	$Fe_2(C_2O_4)_3$	376
Ferric sulphate	$Fe_2(SO_4)_39H_2O$	562
Ferric ammonium sulphate	$Fe_2(SO_4)_3(NH_4)_2SO_424H_2O$	964
Ferrous chloride	$FeCl_24H_2O$	199
Ferrous citrate	$Fe_3(C_6H_5O_7)_23H_2O$	598
Ferrous iodide	FeI_24H_2O	382
Ferrous nitrate	$Fe(NO_3)_26H_2O$	288
Ferrous oxalate	FeC_2O_4	144
Ferrous sulphate	$FeSO_47H_2O$	278
Ferrous ammonium sulphate	$FeSO_4(NH_4)_2SO_46H_2O$	392
Formaldehyde (formalin, *q v.*)	HCHO	30
Formic acid	HCOOH	46
Gallic acid	$C_6H_2(OH)_3COOH$	170
Glycerine	$C_3H_5(OH)_3$	92
Gold chloride (auric)	$AuCl_3$	303·5
Hydriodic acid	HI	128
Hydrobromic acid	HBr	81
Hydrochloric acid	HCl	36·5
Hydroquinone	$C_6H_4(OH)_2$(para)	110
Lead acetate	$Pb(C_2H_3O_2)_23H_2O$	379
Lead iodide	PbI_2	461
Lead nitrate	$Pb(NO_3)_2$	331
Lead oxide	PbO	223
Lithium bromide	$LiBr\ 2H_2O$	123
Lithium chloride	$LiCl\ 2H_2O$	78·5
Lithium iodide	$LiI\ 3H_2O$	188
Magnesium bromide	$MgBr_26H_2O$	292
Magnesium chloride	$MgCl_26H_2O$	203
Magnesium iodide	MgI_28H_2O	422
Magnesium sulphate	$MgSO_47H_2O$	246
Mercuric chloride	$HgCl_2$	271·5
Mercuric cyanide	$Hg(CN)_2$	253
Mercuric iodide	HgI_2	454
Mercurous chloride	HgCl	236
Mercurous iodide	HgI	327
Methyl alcohol	CH_3OH	32
Nickel chloride	$NiCl_2\ 6H_2O$	338
Nickel sulphate	$NiSO_4\ 7H_2O$	281
Nitric acid	HNO_3	63
Oxalic acid	$(COOH)_22H_2O$	126
Platinic chloride	$PtCl_48H_2O$	481

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TABLE II (*Continued*). FORMULÆ

	Formula	Molecular Weight
Potassium bicarbonate	$KHCO_3$	100
Potassium bichromate	$K_2Cr_2O_7$	294
Potassium bromide	KBr	119
Potassium carbonate	$K_2CO_3 2H_2O$	174
Potassium chlorate	$KClO_3$	122·5
Potassium chloride	KCl	74·5
Potassium chloroplatinite	K_2PtCl_4	415
Potassium citrate	$K_3C_6H_5O_7H_2O$	324
Potassium cyanide	KCN	65
Potassium ferricyanide	$K_3Fe(CN)_6$	329
Potassium ferrocyanide	$K_4Fe(CN)_63H_2O$	422
Potassium hydroxide	KOH	56
Potassium iodide	KI	166
Potassium metabisulphite	$K_2S_2O_5$	222
Potassium nitrate	KNO_3	101
Potassium oxalate (neutral)	$K_2C_2O_4H_2O$	184
Potassium percarbonate	$K_2C_2O_6$	198
Potassium perchlorate	$KClO_4$	138·5
Potassium permanganate	$KMnO_4$	158
Potassium persulphate	$K_2S_2O_8$	270
Potassium sulphide	K_2S	110
Potassium thiocyanate	KCNS	97
Pyrogallol	$C_6H_3(OH)_3$	126
Salicylic acid	$(OH)C_6H_4(COOH)$	138
Silver acetate	$AgH_3C_2O_2$	167
Silver bromide	AgBr	188
Silver chloride	AgCl	143·5
Silver iodide	AgI	235
Silver nitrate	$AgNO_3$	170
Silver sulphide	Ag_2S	248
Sodium acetate	$NaH_3C_2O_23H_2O$	136
Sodium biborate (borax)	$Na_2B_4O_710H_2O$	382
Sodium bicarbonate	$NaHCO_3$	84
Sodium bichromate	$Na_2Cr_2O_72H_2O$	298
Sodium bisulphate	$NaHSO_4H_2O$	138
Sodium bisulphite	$NaHSO_3$	104
Sodium bromide	$NaBr\ 2H_2O$	139
Sodium carbonate	$Na_2CO_310H_2O$	286
Sodium chloride	NaCl	58·5
Sodium citrate	$Na_3C_6H_5O_72H_2O$	294
Sodium hydroxide	NaOH	40
Sodium hyposulphite	See Sodium Thiosulphate	
Sodium iodide	$NaI\ 2H_2O$	186

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TABLE II (*Continued*). FORMULÆ

	Formula	Molecular Weight
Sodium metaborate	$NaBO_2$	66
Sodium nitrate	$NaNO_3$	85
Sodium nitrite	$NaNO_2$	69
Sodium phosphate (tribasic)	$Na_3PO_4 12H_2O$	380
Sodium ,, (dibasic)	$Na_2HPO_4 12H_2O$	358
Sodium sulphate	$Na_2SO_4 10H_2O$	322
Sodium sulphide	$Na_2S\ 9H_2O$	240
Sodium sulphite	$Na_2SO_3 7H_2O$	252
Sodium thioantimonate	$Na_3SbS_4 9H_2O$	480
Sodium thiosulphate (hypo)	$Na_2S_2O_3 5H_2O$	248
Sulphur dioxide	SO_2	64
Sulphuric acid	H_2SO_4	98
Sulphurous acid	H_2SO_3	82
Tannic acid	$H_4C_{27}H_{18}O_{17}$	618
Tartaric acid	$(CHOH.COOH)_2$	150
Thiocarbamide (thiourea)	$SC(NH_2)_2$	76
Uranium (uranyl) acetate	$UO_2(C_2H_3O_2)_2 2H_2O$	424
Uranium (uranyl) nitrate	$UO_2(NO_3)_2 6H_2O$	502
Uranium (uranyl) sulphate	$UO_2SO_4 3H_2O$	420
Zinc bromide	$ZnBr_2$	225
Zinc iodide	ZnI_2	319
Zinc sulphate	$ZnSO_4 7H_2O$	287

Equivalent Focus. See FOCAL LENGTH.

Ever-Ready Case. A case so made that the camera can be used without removing it from the case. Usually the camera is locked into the case by a screw engaging with the tripod-bush, and top and front of the case hinge down in one piece to expose the lens and allow access to the shutter-release and other controls.

Expiry Date. Date stamped on a film carton to indicate the probable date by which the film, if unused, will have begun to deteriorate noticeably. (See OUT-OF-DATE FILMS.)

Exposure. The action of submitting any sensitive surface to the action of light, whether in the camera, when enlarging, or in a printing frame, is called "exposure." Correct exposure is the basis of all successful photography, but as in print-making and enlarging there is ample opportunity to experiment by means of small test-strips, we will here restrict ourselves to the consideration of exposure in negative-making. For the fundamental principles underlying exposure, and for a definition of "correct exposure," see SENSITOMETRY. The following notes are purely practical.

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Exposure in negative-making is determined by three factors; the amount of light reflected by the deepest shadows of the subject, the lens aperture in use, and the speed of the emulsion used. In making positives by reversal (colour: cine) it is best to base the exposure on the highlights rather than the shadows.

(1) *Light.*—The amount of light reflected from the subject depends in turn on several factors. In outdoor work it depends on the amount of light available, as determined by time of day and year, by the extent to which the sky is clouded over, on the proportion of the available light which actually reaches the subject, and on the reflecting power of the latter.

For purposes of exposure we need the total effect of all these factors. The simplest and most direct method is to use a photometer in which the apparent brightness of the darkest shadow or the brightest highlight, as seen from the camera position, is directly compared with a standard light. To be accurate, and to cover the very wide range of brightnesses offered by different subjects, a photometer has to be both expensive and bulky, and though one such instrument (S.E.I. Photometer) is available, its application at present lies chiefly in highly specialized and critical work.

In practice the great majority of the more advanced amateurs use a photo-electric exposure meter (*see* EXPOSURE METERS) by which the amount of light reflected towards the lens by the subject as a whole can be directly measured. So long as the subject to be taken does not depart too far in characteristics from the average subject for which the meter is scaled, the exposure required can then be immediately read off from a table or calculator, for any stop or speed of film.

In using a photo-cell meter it should never be forgotten that the light-reading is a measure of the total amount of light reaching the cell from all parts of the subject at which it is pointed. The reading, therefore, gives no direct indication of the depth of the shadows, and hence does not *necessarily* indicate the correct exposure. This defect can be overcome by deliberately pointing the meter at a part of the subject containing shadow *only*, and basing the exposure on the reading so obtained. The meter scales are used normally for calculation, but an artificially high speed-number is allotted to the film. (See EXPOSURE METERS.)

Measurement of the light falling on the subject, which can be done either with a special incident-light photo-cell meter

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having an opal window or by providing a standard white reflector and measuring the light reflected from it by means of a photo-cell meter (Smethurst High-Light system) is to be preferred for reversal work. For monochrome work it is one stage less direct than measuring the shadows, but almost equally informative. Provided that the light measured is that reaching the darker parts of the subject, a simple table or calculator will give the exposure required, with any film or stop, for a subject of average reflecting power. A small allowance has to be made, at least theoretically, for subjects of unusually high or low reflecting power.

Where no means of measurement are available, the light reflected by the subject has to be estimated. While an experienced photographer can do this with tolerable accuracy merely by looking at the subject, and estimating direct the required exposure, the less practised usually rely on tables. In these data are provided by which the three factors controlling light can be estimated step by step.

Accurate tables of the intensity of unobstructed sunlight at different times of day and different seasons of the year form the foundation of all exposure tables. By inspection of the sky, an estimate is next made of the extent to which the sunlight is obstructed by mist or cloud. The proportion of the sky-light that reaches the subject, and the reflecting power of the latter, are generally estimated together by taking account of the " nature of the subject." " Portraits in the Open " and " Portraits under Trees " are two typical descriptions of subjects differing not at all in themselves, but only in the amount of light they receive, while an " Open Seascape " differs from an " Average Landscape " chiefly in the proportion of light which its darkest parts reflect. Although, as is evident, exposures based on tables contain too much guesswork to rank as scientifically precise, yet with tables to aid him, even a beginner can regularly obtain negatives the exposure of which lies within the latitude of his material.

A brief set of exposure tables is printed for reference at the end of this article. It will be noticed that the numbers to be added are effectively logarithms ; that is, each time a figure is added the exposure indicated is multiplied. An addition of two units amounts, throughout the table, to doubling the exposure indicated.

In choosing a figure for " Subject " or " Weather " some discretion is required. It is evident, for example, that a brunette in dark clothes will require more exposure than a

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blonde dressed in white, even though both may be described as "Outdoor Portraits." Similarly, "Dull" is a rather vague description of weather conditions, especially in the larger towns, where a layer of cloud may be blackened to almost any extent with smoke and soot. In view of the wide variations possible under these two headings it is not worth while to go minutely into the several less important factors that may affect exposure.

(2) *Lens Aperture.*—The influence of the diaphragm or stop on exposure is dealt with under the heading DIAPHRAGMS (*q.v.*). It is only necessary to point out here that the majority of modern lenses are marked for a series of stops so chosen that each requires double the exposure that would be needed with the next stop larger. The largest aperture, however, quite often does not fit into the series.

(3) *Emulsion Speed.*—The question of film speeds is discussed under the heading of SENSITOMETRY (*q.v.*) where also will be found a table giving the relationship, for exposure meter purposes, between the various methods of marking film speeds recently or at present in use.

Points Concerning Negative Exposure.

In all exposure calculations, it is important to remember that the exposure to aim for is the minimum correct exposure. Less will give shadows that are either blank or lacking in contrast; more will lead to a loss of sharpness and an increase in graininess, even if tone-rendering remains perfectly satisfactory. Users of large cameras can safely give more, even much more, than the minimum; miniaturists cannot unless they are content with quite small enlargements.

Development must on occasions be taken into account in determining exposure, as many developers of "ordinary" type, such as M.Q. or pyro-soda, as well as most developers of ultra-fine-grain character, demand that exposure be in excess of that needed when an M.Q. borax or similar developer is to be used. With a normal ("minimum correct") exposure, these developers give a negative showing all the characteristics of under-exposure. Allowance for this is best made by regarding the film as being slowed by the developer, and using a suitably reduced speed-number when calculating the exposure.

Older books frequently stressed the importance of a slight yellowness of the light (as, for example, towards evening) in lengthening exposure. Modern material is so strongly colour-sensitive that this factor can now be practically ignored, as

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the intensity of the light, as estimated by eye or a photo-cell meter, is a completely satisfactory guide to exposure.

It is sometimes stated that the contrast of the finished negative can be increased by under-exposure. This ancient fallacy was proved incorrect when Hurter and Driffield published their first characteristic curve (see SENSITOMETRY) in 1890, but it still persists in many quarters, even though one glance at such a curve is enough to show that contrast is *reduced* by under-exposure. Control of contrast is a matter that must be left to the process of development.

Points Concerning Exposure for Reversal.

The aim of exposure-calculations for reversal material (colour transparencies: cine) is to ensure that there is just enough detail and gradation in the highest lights, leaving the shadows to look after themselves. This means that, theoretically, exposure should be based on the light reaching, or reflected from, the brightest part of the subject. Highlight or incident-light meters are consequently the ideal. Nevertheless, a meter simply pointed at the subject as a whole is found, in practice, to indicate correct exposure in all but exceptional cases, as is proved by the success in this field of the modern automatic camera.

Exposures for Near Objects.

In discussing the effect of the lens-aperture on exposure (see under DIAPHRAGMS) it was tacitly assumed that the sensitive film was placed at, or near, the principal focus of the lens—in other words, that the lens-film distance was approximately equal to the focal length of the lens. While sufficiently true for calculating exposures of all normal subjects, this ceases to be true when photographing an object so near the lens that considerable extra camera-extension is required to get the image in sharp focus.

In such cases the effective *f*/number is increased in the same proportion as the extension; using a 6-in. lens racked out 3 in. beyond the normal infinity point, for example, exposures must be calculated for an *f*/number one-and-a-half times that to which the stop-scale is set.

See also EXPOSURE METER, SENSITOMETRY, MOVING OBJECTS, HAND-CAMERA WORK, TELEPHOTO LENS, PHOTO-MICROGRAPHY, ARCHITECTURAL PHOTOGRAPHY. Also BROMIDE PAPER, ENLARGING, LANTERN-SLIDES, etc.

Exposure Tables for Electric Light. See PORTRAITURE.

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Exposure Times for Flashbulbs. See FLASHBULBS, EXPOSURES WITH.

EXPOSURE TABLES FOR DAYLIGHT.

In the exposure tables which follow the effect of the factors film-speed, month and time of day, subject being photographed, stop, and light (weather) are each represented by a number. To calculate an exposure, the appropriate numbers are taken from the tables and added together. Opposite the total in Table VI is found the exposure required.

Example.—It is desired to take a photograph on a film of speed 64 A.S.A. (Table I) at 10.30 a.m. in June (Table II), the subject being an open view (Table III), to be taken at *f*/8 (Table IV) at a moment when the sun is behind a cloud (Table V). The figures from the tables are, in order, 10, 2, 8 and 3. These add up to 23. Table VI then shows that the correct exposure is 1/500th sec.

Special Note.—These tables, used with the recently doubled A.S.A. film speeds, include no safety-factor; that is, they indicate the necessary minimum. The indicated exposure may be doubled by adding 2 to the total before using Table VI.

Exposure Meters. The uses of exposure meters, and the characteristics of the main types, are discussed under the head of EXPOSURE (*q.v.*). The chief types at present in use are the optical photometer and the photo-electric meter.

The Optical Photometer.—Only one such instrument, the S.E.I. Photometer, is at present on the market. The desired

TABLE I.—FILM SPEEDS

DIN. DEGREES	B.S.I. DEGREES	A.S.A. AND WESTON	FACTOR
30–32	43–45	1600–2600	2
27–29	40–42	800–1300	4
24–26	37–39	400–650	6
21–23	34–36	200–320	8
18–20	31–33	100–160	10
15–17	28–30	50–80	12
12–14	25–27	25–40	14
9–11	22–24	12–20	16
6–8	19–21	6–10	18

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Exposure Meters

TABLE II.—NORMAL SUMMER TIME

Month	A.M. 12 to P.M. 2	11–12 2–3	10–11 3–4	9–10 4–5	8–9 5–6	7–8 6–7	6–7 7–8	Month
June	0	0	0	0	1	1	2	June
May	0	0	0	0	1	1	3	July
April	0	0	0	1	1	2	3	Aug.
Mar.	0	1	1	1	2	3	—	Sept.
Feb.	1	1	1	2	3	—	—	Oct.
Jan.	1	2	2	3	—	—	—	Nov.
Dec.	1	2	3	4	—	—	—	Dec.

TABLE IIA.—GREENWICH TIME

Month	A.M. 11 to P.M. 1	10–11 1–2	9–10 2–3	8–9 3–4	7–8 4–5	6–7 5–6	5–6 6–7	Month
April	0	0	0	1	1	2	3	Aug.
Mar.	0	1	1	1	2	3	—	Sept.
Feb.	1	1	1	2	3	—	—	Oct.
Jan.	1	2	2	3	—	—	—	Nov.
Dec.	1	2	3	4	—	—	—	Dec.

In both Table II and Table IIA, the last figure in each line refers to the end nearest midday of the period shown.

TABLE III.—SUBJECTS

Clouds, open sea	0
Distant	2
Semi-distant	4
Nearby, unshaded	6
Nearby, lightly shaded	8
Nearby, heavily shaded	10
Close-up, unshaded	8
Close-up, lightly shaded	10
Close-up, heavily shaded	12
For sidelighting in sunlit scenes, add	2
For back lighting in sunlit scenes, add	4

TABLE IV.—STOPS.

f/2	0	*f*/3·5	3	*f*/5·6	6	*f*/11	10
f/2·5	1	*f*/4	4	*f*/6·3	7	*f*/16	12
f/2·8	2	*f*/4·5	5	*f*/8	8	*f*/22	14

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TABLE V.—LIGHT

Sun unobscured	0
Weak sunlight	2
Sun behind cloud	3
Cloudy, bright	4
Cloudy, dull	6 or more

TABLE VI.—EXPOSURE

No.	Exp.	No.	Exp.	No.	Exp.
21	$\frac{1}{1000}$	32	$\frac{1}{250}$	43	2
22	$\frac{1}{700}$	33	$\frac{1}{125}$	44	3
23	$\frac{1}{500}$	34	$\frac{1}{100}$	45	4
24	$\frac{1}{350}$	35	$\frac{1}{80}$	46	6
25	$\frac{1}{200}$	36	$\frac{1}{60}$	47	8
26	$\frac{1}{150}$	37	$\frac{1}{40}$	48	12
27	$\frac{1}{100}$	38	$\frac{1}{30}$	49	16
28	$\frac{1}{75}$	39	$\frac{1}{15}$	50	24
29	$\frac{1}{50}$	40	$\frac{3}{4}$	51	32
30	$\frac{1}{40}$	41	1	52	48
31	$\frac{1}{30}$	42	$1\frac{1}{2}$	53	64

portion of the subject is viewed through a low-power telescope, into the centre of the field of which a spot of light is introduced by a Lummer-Brodhun cube. This light is derived from a pocket-lamp bulb powered by a small battery, is controlled in brilliance by a rheostat and monitored by a photo-electric cell. The relative brilliance of the subject, as seen through the telescope, and of the spot of light superimposed, is controlled by a system of neutral wedges allowing a match to be made over a range of brightness of 1: 1,000,000. By matching the spot to the deepest shadow in which detail is required, the minimum correct exposure, required for negative work, can be read off with high accuracy. By matching the spot to the highest light in which detail is required the maximum correct exposure, needed in reversal work, can equally be determined.

Photo-electric and Photo-sensitive Meters.—There are two distinct types of photo-electric meter. In one, which is in widespread use, a selenium barrier-cell is illuminated by the light reflected from or falling on the subject; the cell converts

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the energy of the light to electric energy, which is passed through a sensitive microammeter, an electrical instrument which indicates, by a movement of a pointer over a graduated scale, the strength of the current flowing. The second and more recent type uses a cell of cadmium sulphide, the electrical resistance of which changes when light falls upon it. A small battery is here required to produce the current, which is read by a microammeter as before, its magnitude again depending on the strength of the light reaching the cell. The advantage of the cadmium sulphide meter is that it can readily be made to have a sensitivity at least a hundred times higher than that of the barrier-cell type of instrument. At the time of writing, the newer instrument has been announced, but as yet few have reached the market.

With either meter the intensity of the light, whether daylight or white artificial light, can be accurately measured, and this figure, when used in conjunction with tables or a calculator, gives a suitable exposure time and lens aperture for the emulsion speed of the negative material used.

The photo-electric cell does not " run down " with use like an ordinary dry cell (torch battery, etc.), as is sometimes thought ; the energy it gives out is entirely derived from the light that falls upon it. Nevertheless, the photo-cell is liable to deteriorate with time owing to the eventual development of an electrical leakage between its layers, causing its output to fall. In the early stages of this fault it is usual to find that though the meter indicates normally and correctly in dim and medium light, the needle fails to move up as far as it should in a really bright light. In checking the performance of a meter, a test at or near full scale reading should always be included. A deteriorated cell can be replaced at no great expense. The probable life of a photo-sensitive cadmium sulphide cell is as yet not tested in practice, but its structure suggests that its life should be longer, rather than shorter, than that of a selenium cell.

In exposure meters of either type, the photo-cell is usually placed behind a short " grid " or recess so that the angle of incident light is about equal to that of the lens in the camera. This ensures that any possible strong lights outside the field of view of the camera will not influence the meter and so give a false exposure reading. For photographic purposes, the photo-electric cell, which is very sensitive to the ultra-violet band of the spectrum, is covered with a suitable light filter

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to absorb the incident ultra-violet rays, so making its spectral sensitivity approximate to that of the human eye.

This type of exposure meter is of course equally suitable for cine cameras, and many models embody also a scale of the shutter speeds common with most cine camera shutters, *i.e.* 1/16th, 1/32nd, and 1/64th of a sec.

In order to extend the range of the instrument, and make it as sensitive and accurate to very weak light values as to strong sunlight, it has been found necessary in many models to include an electrical resistance which can be placed at will in parallel across the moving coil of the meter, as shown by the dotted lines in the diagram, in order to divert some of the current from the meter when measuring strong light. In other models the grid restricting the angle of view of the cell, and which also often covers a large part of the cell, can be opened to admit more light.

The increased sensitivity of the cadmium sulphide meter can be made use of simply to allow a meter of normal type to be used even in very weak light, keeping the angle of view to approximately that of the camera, or alternatively the angle of view may be greatly restricted to allow readings to be made on any selected part of the subject. Such a meter can have almost the accuracy of an optical photometer.

Standardization and Calibration. The first point to emphasize is that meters cannot validly be compared or tested by pointing them at a source of light such as a lamp. The only satisfactory test-object is an evenly-lit surface filling the whole field of view of the meter. This surface may be an opal plate in contact with the cell-window, an evenly-lit wall, or (as an approximation) an even grey sky.

British Standard 1383/1947 lays down a suitable method of calibration using an opal plate illuminated on the side away from the meter; the amateur may validly use this for comparison of meters, but to check absolute calibration some instrument for measuring the brightness of the opal plate is required.

The Standard also lays down the exposure-level that the meter must indicate. If the brightness of the surface to which the meter is pointed (opal plate) is B candelas per sq. metre, A is the A.S.A. speed to which the speed scale is set, and f the stop, the exposure time should nominally be given by the equation $T = \frac{11 \cdot 3 f^2}{AB}$. Permissible tolerance is half a stop either way.

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Exposure Meters

Using a Photo-Electric Meter.—When a photo-electric meter is pointed towards a subject, the movement of the needle accurately indicates the total amount of light reaching the cell by reflection from the subject. Unfortunately that measurement, taken by itself, bears no necessary relationship to the exposure required, which depends solely on the depth of the deepest shadow in which detail is required. Of this the meter, used as described, gives no indication at all.

If the subject contains a fairly large brightly-lit area, the exposure indicated will be short; the presence or absence of a few dark shadows will make almost no difference to the meter-reading, but a great deal of difference to the exposure required. The conversion of a reading of total light into an exposure indication is thus only possible when both the relative brightnesses and the relative areas of dark and light parts of the subject are more or less standard. The scales of the meter correctly perform this conversion for a subject regarded by the maker of the meter as "average" in this respect, but give quite unreliable results for subjects of abnormal type.

Several possible ways of using the meter to measure shadow-brightness present themselves. The most obvious one is to walk up to the subject and point the meter at some small part of it that is *all* shadow. The reading then given will be proportional to the exposure required, but owing to the total exclusion of bright objects, the movement of the needle will be small. If the scales are used normally the indicated exposure will therefore be far too long; this, however, can be adjusted by working out the exposure for a film ten times faster, or a stop three steps larger, than that to be used in taking the photograph.

Alternatively, the intensity of the light falling on the shadows of the subject may be determined, either by pointing the meter towards the light, or by holding a piece of white paper in a dark part of the subject and measuring the light reflected from it. Again fictitious speed-numbers will have to be used to convert the readings into practical exposures, but once the correct speed-number has been found, exposures should be uniformly accurate.

To find a suitable speed-number, choose some subject of a type with which the method of pointing the meter at the subject as a whole has already been found to be successful. Using this method, work out the exposure in the ordinary way Then go up to the selected shadow and make a fresh

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reading in whichever of the three ways just outlined it is proposed to adopt, and find what speed-number has to be allotted to the film to make the exposure calculated from this new reading come to the same figure as that found by the first measurement. Use of this speed-number, however fantastic it may appear, in connection with the chosen method of measuring shadow-brightness, will give much more reliable results than can be had by just pointing the meter at the subject as a whole.

It should be noted, however, that a spool of eight negatives uniformly under-exposed, and so useless, is far more encouraging as a trial result than a spool of eight printable negatives of widely varying density. The first proves that the method is sound, but that the speed-number chosen is too high. Rectification of this will then give negatives of uniformly correct exposure. A set of negatives all of different density would indicate that meter-readings bear no close relationship to the correct exposure ; in other words, that the method of working adopted is not a sound one, or is not being correctly applied.

The colour sensitivity of a photo-cell approximates closely enough to that of an average panchromatic film to allow the meter to be used in exactly the same way by artificial light as by daylight, using the same speed number for the film.

A note on the use of a photo-cell meter in a light, natural or artificial, which is not strong enough to operate the meter when it is used in the ordinary way, will be found under ARCHITECTURAL PHOTOGRAPHY.

Because of its construction, a photo-electric meter is necessarily a comparatively delicate instrument, and should be handled and treated as such.

Incident-Light Meters.—For reversal work, in monochrome or colour, exposure is best adjusted so that the highlights are represented by the thinnest image that can still retain the gradation, leaving the shadows to take care of themselves. To ensure this, measurement is made, by a photo-cell meter with an opal cover over the cell, of the brightest light falling on any part of the subject. Alternatively the artificial highlight method, which is applicable with a meter not intended for incident-light readings (see EXPOSURE), may be used. Many modern meters are fitted with an optional opal cover to allow them to be used for incident-light measurements: in such cases the opacity of the opal is so adjusted that the normal scales of the meter continue to apply. Where the

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opal plate is fitted by the user, or where the artificial highlight method is used, an artificial speed-number may have to be allotted to the film in order to make the calculating scales give correct readings.

Extinction Meters.—Exposure meters in which a number or design seen against a ground-glass screen is progressively darkened until it is only just visible. In an alternative form, a row of numbers of steadily increasing density is provided, and the eye has to select the darkest that can just be read in the prevailing light. From the estimate so made of the brilliance of the light the exposure is calculated. Except in practised hands, the fact that the sensitivity of the human eye varies, according to the prevailing light, over a range of more than a hundred to one, tends to make all instruments of this type very unreliable in their readings.

Actinometer (Sensitive Paper) Meters.—In these meters, now obsolete, the intensity of the light falling on the subject was measured by noting how long a scrap of sensitive paper exposed to it took to darken to match a standard tint. The Wynne and Watkins (" Bee ") meters, once widely used, were the best known of this type.

Calculators.—Exposure calculators are identical in principle with exposure tables (see EXPOSURE). The calculator-mechanism is simply a substitute for the alternative process of adding a series of numbers.

Exposure Value Scale. Scale found on certain shutters in which the speed-setting ring is mechanically locked to the aperture-setting in such a way that turning the speed ring to double or halve the time of exposure closes or opens the iris to keep unchanged the amount of light passed during the exposure. All such identical, but differently realized, exposures are allotted the same exposure-value, and an exposure-meter intended for use with a shutter of this type need have no stop or shutter-speed scales, both being replaced by a single exposure-value scale. The meter needs no calculating disc; all that is necessary is a series of interchangeable scales, one for each film-speed, over which the needle moves; the figure on which it comes to rest is the appropriate exposure-value. The iris of the camera is then adjusted, without altering shutter speed, till the indicated exposure-value is reached; shutter speed and aperture are then locked automatically by the removal of the finger, and the speed-ring of the shutter is turned, if necessary, to give the required speed or stop.

A recent American Standard specification proposes an

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extension of this idea. The exposure meter is to be graduated in " light-values ", and the sensitivity of the film expressed by a " film-speed value ". Both are small whole numbers, and when added together they give the exposure value. Furthermore, the shutter-speed and stop scales are to be replaced by simple scales of numbers, so chosen that their sum is the exposure value. A change of one unit in any of the four scales corresponds to a doubling—from 50 to 100 A.S.A., from 1/100 sec. to 1/50 sec., or from *f*/11 to *f*/8.

Extension Flash. A flash used away from the camera, generally in conjunction with one attached to the camera itself. Some flashguns (*q.v.*) have sockets to which an extension flash, firing at the same time as the on-camera flash, can be connected. In using, on the camera, a battery-capacitor flashgun (Fig. 2 under FLASHGUN) the extension flash need merely be connected in series with the on-camera bulb.

Extension Tubes. Tube inserted between lens and camera-body to provide extra extension, usually for focusing near objects. Particularly frequently used with miniature cameras fitted with focal plane shutters. A tube described as " 1:2 " is intended to give sharp focus at such a distance that the object photographed is reproduced on the negative at half natural size.

If a tube gives a ratio of reduction r, then—

(1) its length must be $f \div r$, where f is the focal length of the lens with which it is to be used

(2) the object must be placed at a distance $(r + 1)f$ from the node of admission of the lens, the focusing of the latter being set for " Infinity."

If the extra extension provided by a tube is e, then the ratio of reduction it will give is equal to $f \div e$.

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F

"F" Numbers. See DIAPHRAGMS.

Fabrics, Printing on. See CANVAS and SILK.

Faded Prints. Various methods for renovating faded prints have been suggested, but all are risky, and are best avoided. The desired result can in almost all cases be more readily attained by copying the print and making fresh prints from the new negative. This subject is dealt with under COPYING (*q.v.*).

Fading. The principal causes of the fading of both negatives and bromide or gaslight prints are insufficient fixation and insufficient washing. The former leaves an insoluble silver thiosulphate in the paper, and this is more sensitive to atmospheric influences than the pure metallic silver forming a properly-made image. The sulphur present in the thiosulphate is a further source of potential fading. Incompletely-fixed prints eventually turn yellow or brownish in the whites as well as showing deterioration and fading of the image.

Insufficient washing again leaves thiosulphate (hypo) in the gelatine, and this in time attacks the image and causes fading. In this case the whites are generally unaffected.

In general, sulphur compounds, and particularly sulphides, are the worst enemies of the permanence of a photographic image. Where much coal is burnt, and particularly in large towns, the sulphur compounds present in the atmosphere will in time attack the image. One of the surest ways of rendering a bromide print permanent is to tone it by the sulphide process (see TONING); the image then is composed of silver sulphide and so is practically inert towards atmospheric sulphur compounds. Toning with gold, which hardly changes the colour, also adds considerably to permanence. But an ordinary bromide print, fully fixed and reasonably well washed,

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will last the better part of a half-century at the very least. Gaslight and chloro-bromide prints are more sensitive to fading; ideally they should always be treated with a hypo-eliminator (*q.v.*) before being dried.

Prints by the now obsolescent print-out processes are much less stable, as the image is not of pure silver but of various compounds of more or less indeterminate character. These are much more readily attacked by atmospheric influences. The same may also be said of bromide prints toned by processes other than the sulphide process.

Carbon, Carbro, bromoil, oil and gum-bichromate prints are as permanent as the colouring matter used in their preparation. If a permanent pigment such as carbon (lamp-black) is used they should last as long as the paper itself remains intact.

External Sources of Fading other than the atmosphere are sometimes found in the mount or mountant used. Hypo is used as an " anti-chlor " in the preparation of many papers, and if any remains in a mount (see test in the article on WASHING) it may cause deterioration. Particularly is this the case when prints are mounted in an album, as the face of the print comes into direct contact with the opposite page. Where permanence is important dry mounting (see MOUNTING) is recommended, as the layer of shellac effectively isolates the print from any impurities in the mount. Further protection can be given to a print by treating it with dope or encaustic paste (see these entries). See also WASHING.

When mounting by processes other than dry-mounting, the mountant chosen should always be one offered by its manufacturer as suitable for photographic use. Caution should be used with rubber mountants; it is not unusual for prints with which they have been used to develop reddish stains after a few months, especially in places where the mountant was applied thickly or had not dried sufficiently before the print was laid down. Sometimes such stains disappear if the print is left exposed to air for some time, preferably after separating it from the mount.

Fahrenheit. See THERMOMETRY.

Farmer's Reducer. See REDUCTION (OF DENSITY).

Federations. Photographic societies have formed themselves, for mutual help, into Federations, of which there are ten in the United Kingdom. Each society pays a small subscription, in return for which the Federation organizes

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panels of judges and lecturers, sponsors an annual exhibition, and performs various other services.

See also PHOTOGRAPHIC ALLIANCE.

Feer-type. This process, patented by Dr. Adolf Feer in 1889, is founded on the property possessed by diazo compounds (see DIAZOTYPE) of forming diazo-sulphonic salts with sodium sulphite ; and these diazo-sulphonic compounds, when mixed with phenols or amines and exposed to light, are decomposed, and the diazo compound is set free and forms a colouring matter—a positive is thus obtained from a negative.

Ferric Ammonium Citrate. (Fr., *Ammonio-citrate de fer ; Citrate ammoniacal de fer ;* Ital., *Citrato di ferro ammoniacale ;* Ger., *Citronensaures Eisenoxydammon*). Also known as ammonio-citrate of iron. Two varieties of this compound exist, the green and the brown. Neither is crystallisable under usual manufacturing conditions ; they are usually sold as scales formed by the evaporation of solutions to dryness. They have no very definite composition, but the green form appears to correspond approximately to $2FeC_6H_5O_7$; $(NH_4)_3C_6H_5O_7$, and the brown form to $FeC_6H_5O_7$; $Fe(OH)_3$; $(NH_4)H_2C_6H_5O_7$. Both are very soluble. The salts are used in preparing sensitive paper for cyanotype (*q.v.*) and other printing processes. The green variety produces the faster paper. The solid salts keep well in sealed bottles protected from light. Solutions are liable to grow mould.

Ferric Ammonium Oxalate. (Fr., *Oxalate ammoniacal de fer ;* Ital., *Ossalato di ferro ammoniacale ;* Ger., *Oxalsaures Eisenoxydammon*). $Fe_2(C_2O_4)_33(NH_4)_2C_2O_46H_2O = 856$. Greenish-white crystals which are partially reduced by light to the ferrous state. 90 parts dissolve in 100 parts of cold water. Used in platinotype and kindred processes.

Ferric Chloride. (Fr., *Perchlorure de fer ; Chlorure ferrique ;* Ital., *Cloruro ferrico ;* Ger., *Ferrichlorid, Eisenchlorid*). $FeCl_3 = 162{\cdot}5$. Also known as perchloride of iron. Generally supplied in yellowish-red masses which are very deliquescent. 100 parts of water at 60° F. will dissolve about 85 parts of ferric chloride. Soluble also in alcohol and ether. Used for preparing cyanotype paper, and for etching copper and zinc. (See PHOTO-MECHANICAL PRINTING PROCESSES.)

Ferricyanide of Copper, Toning by. See TONING.

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Ferricyanide Reducer. See REDUCTION.

Ferroprussiate Processes. See CYANOTYPE.

Ferrotypes or Tintypes. Originally these were positives taken by the wet plate process on thin iron plate coated with brown or black varnish. Ferrotype plates coated with a thin film of a highly argentiferous gelatine emulsion are now prepared commercially for use with semi-automatic cameras.

Ferrous Oxalate. (Fr., *Oxalate ferreux ;* Ital., *Ossalato ferrico ;* Ger., *Eisenoxalat*). FeC_2O_4. The active constituent of the ferrous oxalate, or iron, developer. (See *Ferrous Oxalate,* under DEVELOPMENT.) Ferrous oxalate is very sparingly soluble in water, but dissolves comparatively freely in a solution of an alkaline oxalate.

F.I.A.P. Initials of the Féderation Internationale de l'Art Photographique, an international body the members of which are the associations of amateur photographic societies of the various countries. The Swiss journal *Camera* is its official organ, and its activities consist, in the main, of organizing international exhibitions and portfolios.

F.I.B.P. Fellow of the Institute of British Photographers (*q.v.*).

Field Camera. Camera used on a stand. (See CAMERA.)

Field, Depth of. See DEPTH OF FOCUS.

Field of a Lens is the circular area illuminated by the lens, the diameter of which is usually expressed in inches or degrees, but is sometimes expressed in terms of the focal length. The extent of surface which a lens will illuminate is independent of the diameter of the diaphragm aperture, but the area of sharp focus is affected by the diameter of the stop. (See LENS, WIDE-ANGLE LENS, and ANGLE OF VIEW.)

Film. The thin pellicle of skin or sensitive material on plates or paper is spoken of as the film, although the term is more generally applied to celluloid coated with sensitive emulsion for exposure in the camera. (See FILMS.)

Film Hardening. See HARDENING AGENTS, HARDENING FIXER, HARDENING STOP-BATH, and SCRATCH-PROOF.

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Film Pack. A packet of flat films (usually twelve) in a metal-and-cardboard container so devised as to allow the whole to be loaded in daylight into a film-pack adapter (*q.v.*) and used in a camera designed for plates. Each film is backed with a piece of opaque paper which narrows to a strip at the bottom of the film. These strips are brought up behind the films and their ends project as tabs through a light-trapped slot at the top of the pack. After exposure, the projecting tab corresponding to the film just exposed is pulled out, drawing the film round the base of the unexposed films to the back of the container. To enable the pack to be put into the adapter in daylight, an opaque cover, also equipped with a tab, is placed in front of the first film. The tab of this "safety cover" (usually marked "0") has to be pulled out before making the first exposure. (See also FILMS.)

Film packs are no longer made in Great Britain, but imported packs are from time to time available.

Film Pack Adapter. Abbreviation, F.P.A. A holder for film-packs (*q.v.*) which is inserted into a plate camera in the same manner as a dark slide. Like a slide, it has a pull-out shutter over the front, allowing the adapter to be removed from the camera for focusing. The back, shaped like a shallow box, usually hinges open to allow a used pack to be removed and a new one inserted. This can be done in daylight, as in an unused or completely-used pack the films are protected from light.

Films. The disadvantages of glass when used as a support for the sensitive material—which are its weight, its bulk, and liability to fracture—induced many experimenters in the past to search for a light, flexible support which might be used as a substitute. On the introduction of gelatine emulsions the search for a substitute received great impetus. Woodbury, in 1871, suggested rollable films; Warnerke, in 1876, used gelatine emulsion spread on paper, from which it was afterwards stripped; Pumphrey, Vergara, and others followed; but it was not till the use of celluloid by Carbutt in 1884 that a fully satisfactory material was found.

Films have now become almost universal, and are supplied as cut or sheet film for loading into the dark-slides of a plate camera, as roll film, or as 35-mm. perforated film in cassettes (*q.v.*). Roll films, introduced by the Eastman Kodak Co. in 1891, are in lengths rolled, in company with an opaque paper

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backing, on spools; the cassette is a tube usually containing a spool on which is wound a length of bare film, the end of which emerges through a light-trapped slot in one side of the tube. In the absence of backing paper, perforations along the edge of the film, usually 35 mm. wide overall, are used to control the advance of film from one exposure to the next. The film is rewound back into the cassette after all frames have been exposed.

A spool of film is inserted at one end of the camera, and the paper is drawn across the picture-opening and attached to a second empty spool. The camera is now closed, and the paper wound across the camera until the beginning of the strip of film is in place for the first exposure. This is indicated by the appearance of a number, printed on the back of the paper, in a small red window in the back of the camera. As each exposure is made the film is wound along, still using the numbers as a guide, and when all are exposed the end of the film, together with the remaining length of backing paper to cover it, is wound off on to the originally empty spool and can be removed from the camera in daylight.

Types of Film.—Recent developments in emulsion-making are producing films with new characteristics. Up till 1954 most makers offered an orthochromatic (" chrome ") film of speed about 80 A.S.A., a panchromatic film a trifle slower, and a second pan-film of speed about 160 A.S.A. In addition most makers had a special fine-grain film (in some cases only in 35-mm. size) of speed about 25 A.S.A. In 1955 British makers added to their range a high-speed film (up to 650 A.S.A.) while on the Continent thin-emulsion films, of low or moderate speed (20 to 40 A.S.A.), and having low latitude but giving exceptionally sharp negatives of low graininess, came to the fore.

Since that time all makers have produced films offering new compromises between film-speed and grain on the one hand, and between sharpness of image and exposure-latitude on the other. The success of even those with little photographic experience in obtaining consistently good results on reversal colour film, which has very little latitude indeed, has caused the manufacturers to realize that the high latitude built into films in the past could easily be dispensed with, with the result that all modern films have considerably higher acutance than their counterparts of a few years ago, even though in most cases the name of the film remains unchanged. The

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highly orthochromatic "chrome" film, until a few years ago probably the most popular type, has practically vanished; except for one or two imported roll films, all 35-mm. and roll films are now panchromatic.

The suffix "chrome" as in Kodachrome, Ektachrome and more recently Ilfachrome, may eventually become the distinguishing mark of a reversal colour film, but at the time of writing there is no internationally accepted standardization of nomenclature; the suffix "color" is used for some reversal films (Gevacolor; Agfacolor) as well as for negative colour films (Ilfacolor, Kodacolor).

Processing Roll Film.—Roll films are now almost always processed in a tank by "time and temperature" (see DEVELOPMENT). In the absence of a tank it is easiest to develop in the dark-room by the "see-saw" method, drawing the film to and fro through the developer. To ensure even development, it should first be "see-sawed" through water until it is limp.

Another method sometimes proposed is to hold one end of the film only, and let the other end roll up and unroll in the dish as the hand is raised and lowered. A small deep dish is best for this. This procedure is chiefly notable for the remarkably fine crop of scratches and abrasions that the finished film shows.

Even with the see-saw method, it is so difficult to avoid scratching the face or back of the film that the use of a tank is greatly to be preferred. The long lengths of 35-mm. film used in miniature cameras (1·64 metres, or about 5¼ ft.), are quite impossible to handle unless wound on a reel or drum. (See DEVELOPING DRUM.)

Cut Films (*q.v.*) may be handled separately like plates, or in batches like pack films. Owing to their greater stiffness, extra care must be taken that the corner of one film does not scratch the emulsion of another.

Filmstrip. Term applied to a length of film, usually of width 35-mm., bearing a series of transparencies, in monochrome or colour, that are intended to be projected as a connected sequence. On filmstrips prepared for educational and similar purposes each frame is usually 18 × 24 mm., but frames size 24 × 36 mm. are frequently found. The preparation of a filmstrip by contact printing from miniature negatives is described in the section *Miniature Transparencies* under LANTERN SLIDES.

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Film-strip projectors normally allow for the rotation of the carrier through 90° to permit projection of upright and horizontal pictures from the same strip, but many have rotation in one direction only. British Standard No. 1917:1952 lays down the relative positioning of upright and horizontal pictures, as well as other details: briefly, when the strip is held so that horizontal pictures are seen as they should appear on the screen, vertical pictures have their base to the right.

In the preparation of filmstrips for lecture illustrations and the like it is often preferred to make the strip, not directly from the original negatives, but from a set of bromide enlargements all of the same size, depth, and contrast. These are set up in turn before a suitable camera—any miniature with close-up focusing accessories will serve—and photographed on a slow non-colour-sensitive film capable of giving good contrast. If only one strip is wanted, the exposed film can be processed by reversal (see REVERSAL) to give positives direct, but if a large number of strips is wanted for sale it is better to develop the film to give normal negatives, and to print these by contact on to slow 35-mm. film in an automatic printer through which negatives and positive film are fed together.

It is equally possible to apply reversal processing to the film exposed in the camera on the original subjects, so obtaining, directly, positives for projection. These can be left in strip form, or cut up and mounted individually as slides, as is customary with reversal colour film.

For further details, see *35-mm. Filmstrip Technique*, by Peter Hansell, published by Ilford Ltd.

Filter. Also known as *colour filter*, *light filter*, *colour screen*, *ortho screen*, *yellow* or *green screen* or *filter*, and other recognisably similar terms.

Reference to the article COLOUR-SENSITIVE EMULSIONS will show that although emulsions of this type have been sensitised to green, yellow, and perhaps also orange and red light, their sensitivity to blue and violet light remains excessive. Blue objects are therefore shown lighter in the photograph than they appeared to the eye.

Suppose that we are photographing two patches of colour, green and blue, which have been so adjusted in tint that to the eye they appear of equal depth. Even on a colour-sensitive emulsion, the blue patch would photograph lighter than the green. If now we put over the lens a coloured glass that passes all the green light without obstruction, but

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absorbs a proportion of the blue light, the amount of the latter reaching the film can be reduced until its effect is exactly equal to that of the green light reflected from the second patch of colour. The two patches will now photograph as though they were of equal depth of tone, so reproducing in monochrome the effect seen by the eye. The coloured glass in question is a light filter.

If a glass absorbs blue light only, the light it passes will be white light with some of the blue left out. To the eye, this will appear yellow. A yellow filter is therefore chosen for most purposes, for it is mainly to blue that the emulsion is over-sensitive. But it must on no account be forgotten that though it appears simply yellow, the filter is also passing red, orange, and green light almost without obstruction, as well as letting through some portion at least of the blue and violet.

A little consideration will show that the greater the sensitivity of a plate to green and yellow, the less blue light will have to be absorbed by the filter to reduce the impression made by blue light to the correct level. The more colour-sensitive the emulsion, therefore, the paler the filter needed for adequate correction. It is further evident that the greater the contribution made to the total sensitivity of the emulsion by its sensitivity to green and yellow light, the less increase in exposure will be needed by a filter which cuts off, say, nine-tenths of the blue light.

Although the fact that the filter absorbs light must always mean that its use involves a compensating increase in exposure, the paleness of the filters that suffice to cut down blue adequately with modern emulsions, combined with the fact that these emulsions derive a very considerable part of their sensitivity from colours other than blue, means that the extra exposure needed is not very great. At the beginning of the century an orthochromatic plate—initially very slow by modern standards—required for satisfactory colour-correction a filter needing an increase of some thirty times in exposure; with the fast panchromatic films now available a filter requiring no more than a doubling of exposure gives all the correction needed. With the old plate mentioned above the same filter might have necessitated perhaps a ten times increase, and even then would have given insufficient correction.

It will be evident that "colour-correct" reproduction will not always be desirable, for two adjacent areas of different colour but equal visual brightness, though sharply distinguished

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in the original subject by their colour contrast, may merge together in the print. In such cases departure from true correction is called for; it is achieved by using a filter that transmits less of the light of the colour of the object it is desired to darken than does a "correct" filter. In the copying of paintings, for example, such incorrect filters, known as contrast filters, are often called for.

Similar conditions can arise in less specialized work; to make a cloud or a sunlit building stand out from the blue sky behind it, a deep yellow, orange, or even red filter may be used to render the sky more darkly. In this connection it is important to note that the deep blue sky of a very clear day is not only inherently darker, but is much more markedly darkened by filters, than is a sky of a more watery blue. Care must be taken not to over-filter on very clear days, especially when working at high altitudes or in a Mediterranean climate. In such circumstances, even when no special correction is desired, the use of a U.V. filter absorbing ultra-violet light is to be recommended. In its absence there may be some slight loss of definition and distant objects may be partially hidden by a haze not visible to the eye; with colour film there will be a decided blue bias.

With monochrome film the exact depth or tint of a filter is not of great importance, but with colour film there is very little latitude of choice. Naturally no deeply tinted filter can be used, or the resulting print or transparency will have a heavy colour bias of the same tint as the filter. Nevertheless filters are widely used, their purpose being to adjust the colour-temperature of the prevailing light to match that for which the colour-rendering of the film has been adjusted by the makers. Further details will be found under COLOUR PHOTOGRAPHY, but for practical recommendations it is essential to consult the literature issued in connection with the particular film in use.

Filters can be bought in several forms, of which the cheapest is as sheets of dyed gelatine. These are satisfactory for experimental work, but their glazed surface is too easily rendered dull by moisture or friction for them to be of much permanent value. Even a finger-mark will render such a filter useless. The most practical way of using a gelatine filter is by leaving it permanently in place behind the front combination of the lens. It should be cut to shape between pieces of stout paper or thin smooth card to prevent damage in handling. A glass filter may consist either of a gelatine filter

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cemented between glass plates, or of a single piece of glass coloured in the mass. The former tend to be more desirable on scientific grounds (accuracy of tint, maximum correction) but are in general less durable and less convenient in use. The range of filters obtainable in gelatine (cemented or plain) is very many times wider than that of those to be had in the form of coloured glass.

In either case the glass must be plane-parallel if the definition of the picture is not to suffer, and where lenses of large diameter are in use the most accurately-ground optical flats (*q.v.*) are necessary. Carefully selected patent plate glass is sufficiently good for all ordinary amateur work.

Most of the makers of sensitised material make filters specially adjusted to their own emulsions, but of necessity the mounts they supply (save to special order) are of the general-purpose type that fit, by means of springs, lenses of a fairly wide range of diameters. It is rare that a lens-hood can be used in conjunction with such a mount. Camera makers, on the other hand, supply filters in mounts designed for their particular instruments, and in many cases supply a lens-hood that can be used at the same time as the filter, but it is evident that the filter itself is not calculated for the emulsions of any one particular maker. The photographer has to choose for himself whether he will have a filter to suit his camera or to suit his film. The former is generally preferred in monochrome work, the latter is practically essential for colour.

Graduated Screens, *Graduated Filters*, or *Sky-filters*, are yellow or green filters in which the colouring varies from fairly deep at one end to colourless at the other. If placed well in front of the lens, such a filter can be adjusted so that the coloured part covers the sky while the clear part covers the landscape. Although a special mount is required, these filters have the advantage that they can be used to give good cloud-rendering without any increase in exposure being necessitated by their use.

Multiplying Factors.—The increase in exposure necessitated by a filter depends, as already made clear, on the colour-sensitivity of the emulsion. Although neither all orthochromatic nor all panchromatic films are alike in this respect, it may be taken as approximately correct that a fairly light yellow filter will require a doubling of exposure with an ortho film, while with a panchromatic film the increase is too

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small to be worth making. With a deep yellow filter, increases respectively of 4 times and double will be about correct. Orange and red filters, for panchromatic films only, will need increase of perhaps 5 and 8 times respectively; more, usually, with the slower films than with the faster. Yellow-green and green filters need an increase of 2 to 3 times with most panchromatic films.

The Preparation of Filters.—Filters may be made by coating glass with colourless gelatine and then staining them by immersion in a solution of a dye. Alternatively, the dye may be incorporated in the gelatine before coating. A photographer desirous of making his own filters will, however, be very much better advised to buy a ready-prepared gelatine filter, which will only cost him a few pence, and to cement it up between suitable glasses.

The glasses, which should be best quality patent plate, may be bought cut to the required size. The cement used is Canada balsam. Dilute this with xylene till it is about as thick as glycerine, pour a small pool on to the centre of one of the glasses, and spread it more or less evenly over the whole surface with a glass rod. Lay the gelatine on this, cover it with clean card and press out excess of balsam. Now spread balsam, as before, on the filter, press the second glass firmly down, and make sure all excess balsam and all air-bubbles have been pressed out. Leave under pressure for some days to dry, and then waterproof the edges with celluloid varnish.

See *Colour Filters*, by Wakefield (*Photofacts* Series No. 4) and *All About Filters*, by Jacobson (*Photo-Guide* Series No. 3).

Filters for Three-Colour Work. See COLOUR PHOTOGRAPHY. See also COLOUR-SENSITIVE EMULSIONS.

Filtration. In most cases such filtering as is required for photographic operations is done through a wad of cotton-wool pushed into the neck of a funnel. Really finely-divided precipitates cannot be filtered out by this, and for these more exacting cases a filter-paper should be used. This is a pure paper not dissimilar from blotting-paper, sold ready-cut into circular discs. For use, a disc is folded into four quadrants, and one of these is opened out to form a conical cup. This is fitted into a glass funnel, and the liquid to be filtered is poured into it.

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Finder. See VIEW-FINDER.

Fine-Grain Development. Until fairly recently only the slowest emulsions, normally developed, gave negatives that would stand considerable enlargement without giving a grainy image, and in consequence many special fine-grain developers, in some cases designed by film-makers but often invented by chemical firms or even amateur experimenters, have been used in the past. With the improvement in negative emulsions, need for special developers to control graininess has greatly diminished, and there is nowadays a very general tendency to use slower films, to expose them less generously, and to develop in solutions laying no claim to special fine-grain properties. (See also BEUTLER METHOD.)

As already suggested, the most fundamental way of controlling graininess is by choice of emulsion. Modern films combine a reasonably high speed (up to perhaps 100 A.S.A.), with a freedom from grain that allows of making enlargements of several diameters even when an ordinary (non-fine-grain) developer is used. With almost any fine-grain developer, such a film will give enlargements of 10 to 20 diameters before the structure of the image becomes obtrusive. Faster films, however, are grainier, and special precautions are generally necessary when developing these.

Another factor of the highest importance is the exposure given to the film. Two prints, made from negatives that received different exposures but were developed together, may be identical in depth and contrast, but that made from the more fully exposed negative will show more graininess. For the finest grain, it is therefore essential to give an exposure only just long enough to ensure good reproduction of the shadow tones. This exposure is generally referred to as the "minimum correct exposure." (See SENSITOMETRY.)

From the practical point of view, avoidance of the "clumping" of grains during development is a most important matter, as even in the fastest emulsion the actual grains are exceedingly small. The graininess that is seen in an enlargement from a grainy negative is therefore caused, not by individual grains, but by agglomerations of grains.

The more energetic the developer used, and the longer it is allowed to act, the larger and more obtrusive will these agglomerations be. A fine-grain developer is essentially one which is gentle in its action, and even in this development is only carried far enough to give a soft negative, suitable for printing on a moderately contrasty grade of paper.

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The energy of a developer may be kept down either by choosing an inherently non-energetic developing agent, such as paraphenylenediamine, or by using a more energetic developing agent, such as metol, and keeping the amount of alkali in the solution so low that its action is gentle. Both types of developer are in regular use. An additional line of attack is furnished by the use of solvents of silver bromide (*e.g.*, a sulphite, a thiocyanate, or a bromide) which, by their tendency to dissolve away the edges of the grains, reduce their tendency to agglomerate during development. Developers of this last type, though they have been popular in the past, are now considered dangerous unless officially recommended for the particular film in use, for with many modern emulsions they can give rise to serious dichroic fog.

Since a solvent can reduce the amount of silver deposited as a result of a given amount of light action, the presence of an excessive amount of a solvent of a silver bromide makes extra exposure necessary. So also does the use of a developing agent of very low energy, which is usually incapable of bringing out lightly exposed detail that could have been developed up with a more energetic developer. In effect, therefore, a film may be slower when a fine-grain developer is used. This fact has led to the introduction of a number of formulae offering different degrees of fineness of grain in exchange for different degrees of loss of speed.

At the present time the most widely used fine-grain developers are proprietary preparations the formulæ of which have mostly not been disclosed.

Formulæ Based on High-Energy Developing Agents.

D.76.—Although it was originally put forward as a fine-grain developer, the M.Q. borax formula of the Eastman Kodak Company of America, universally known as D.76, has now become a standard all-purposes developer in all amateur work. So much so, indeed, that it is nowadays customary to regard the official film-speed ratings as correct for D.76 or a similar developer.

The high proportion of sodium sulphite, which acts as a mild solvent of silver bromide, ensures that grain shall be moderately fine, while it also appears that the sulphite helps to maintain the speed of the film.

The formula for D.76, with those of various related developers, is given in *Choosing a Developer* under Development, but as it has served as a starting-point for formulæ of more definite fine-grain type, it is repeated here for reference:

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Fine-Grain Development

Metol	17½ gr.	(2 gm.)
Sodium sulphite (anhyd.)	2 oz.	(100 gm.)
Hydroquinone	44 gr.	(5 gm.)
Borax	17½ gr.	(2 gm.)
Water to	20 oz.	(1000 c.c.)

Ilford ID.68—A phenidone-hydroquinone (PQ) developer similar in characteristics to D.76 or ID.11, but showing less change in activity during use.

Sodium sulphite (anhydr.)	2 oz.	(100 gm.)
Hydroquinone	45 gr.	(5 gm.)
Borax	18 gr.	(2 gm.)
Boric acid	9 gr.	(1 gm.)
Potass. bromide	9 gr.	(1 gm.)
Phenidone	1¾ gr.	(0·2 gm.)
Water to make	20 oz.	(1000 c.c.)

This solution is used undiluted, and development times are as for D.76—7 to 11 minutes at 68° F.

Metol-Sulphite. — Slow-working and gives finer grain than most metol or M.Q. formulæ. Specially suited for subjects of very high contrast, as it develops shadow detail without blocking high-lights.

Metol	130 gr.	(15 gm.)
Sodium sulphite (anhydr.)	610 gr.	(70 gm.)
Potassium bromide	9 gr.	(1 gm.)
Water to	20 oz.	(1000 c.c.)

Development Time.—Up to 25 or 30 minutes at 65° F. with the fastest films.

Exhaustion.—No precise data available, but the large proportion of metol present suggests that exhaustion would be slow.

D.23.—A simple and effective Kodak formula containing metol and sulphite only.

Metol	65 gr.	(7·5 gm.)
Sod. sulphite (anhydrous)	2 oz.	(100 gm.)
Water to	20 oz.	(1000 c.c.)

Development Tine.—22 min. at 68° F. for the fastest films. Average roll films, 17 min.

Emulsion Speed.—Slightly less than with D.76.

Exhaustion.—One litre (35 oz.) will develop eight rolls of film (about 80 sq. in. each) before loss of emulsion speed becomes

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excessive. Each film requires 10 per cent. longer development time than the last. For replenisher, see below.

Grain.—Slightly finer than D.76.

D.25.—Identical with the D.23 formula above except that the activity is reduced by the addition of 15 grams (130 grains) of sodium bisulphite. It is important that this should be pure, or development times may be badly upset.

Development Time.—22 minutes at 77° F. for the fastest films; average roll films 17 min.

Grain.—Slightly finer than D.K.20; a good deal finer than D.23 or D.76.

Emulsion Speed.—Average about 60 per cent. of that found with D.76.

Exhaustion.—As D.23, but increase time by 15 per cent. for each film after the first. For replenisher, see below.

Replenisher for D.23 and D.25.—The life of both D.23 and D.25 may be extended by adding the following replenisher at the rate of ¾ oz. per film up to 25 films per original 35 oz. for D.23, or, for D.25, 1¼ oz. per film for the first 12 films per original 35 oz. and ¾ oz. per film thereafter up to a maximum of 25 films.

Metol	88 gr.	(10 gm.)
Sod. sulphite (anhydr.) .	2 oz.	(100 gm.)
Sodium metaborate (Kodalk)	175 gr.	(20 gm.)
Water to . . .	20 oz.	(1000 c.c.)

When using the replenisher the development time remains unchanged throughout the life of the developer.

Formulæ Based on Low-Energy Developing Agents.

At one time paraphenylenediamine, a developing agent of low activity, was widely used for fine-grain development, especially in U.S.A., but was more recently used, in Britain at any rate, chiefly in the form of Meritol, an addition-compound of paraphenylenediamine and pyrocatechol in molecular proportions. With many modern films paraphenylenediamine, in any form, is liable to give dichroic fog, and developers of this type can no longer be unconditionally recommended.

Diluting Fine-Grain Developers.—To avoid the variation of development time and other uncertainties brought about by using the same solution repeatedly, some workers dilute a fine-grain developer, use it once, and then discard it. The diluted developers generally give a slightly coarser grain, but the difference is not large. Care must be taken not to be too

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economical; the quantity of undiluted developer used must be sufficient for the work it has to do.

Development time is *not* proportional to dilution with fine-grain developers; each formula has to be experimented with individually. For example, with one fine-grain developer diluted to about four to five times normal volume, it is only necessary to develop for double the normal time.

Two-Bath Development.

For subjects of high contrast, into which class most artificial light work falls, a two-bath developer has special claims to attention. The principle is simply a variant of the old water-bath development. The film is partly developed in a low-alkali developer, and then transferred, without washing, to a solution of an alkali. In this the developer carried over in the film is quickly exhausted in the highlights, but continues to work in the shadows until it diffuses away (about 3 minutes.) In this way full shadow detail is obtained without blocking the highlights. For many subjects the deformation of the characteristic curve to which this behaviour corresponds is distinctly helpful.

A characteristic of this type of developer is that it is remarkably insensitive to changes in development time, owing to the fact that the extent of development in the second bath is limited. A full discussion of the method will be found in *J. Soc. Motion Picture Engineers*, July, 1933, where it is pointed out that it is desirable (at all events for bulk work) to devise the developers to suit the film to be used and the value of gamma required.

A general purpose developer issued by Leitz Ltd., for amateur use is as follows:—

A.	Metol	45 gr.	(5 gm.)
	Sodium sulphite (anhydr.)	880 gr.	(100 gm.)
	Water to . . .	20 oz.	(1000 c.c.)
B.	Borax	88 gr.	(10 gm.)
	Water to . . .	20 oz.	(1000 c.c.)

Keeping Properties.—Excellent.

Development Time.—Medium speed films (50 A.S.A.) 4 minutes, fastest films up to 10 minutes, in A at 65° F., then

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transfer, without washing, to B for 3 minutes. Time in B is not critical.

Exhaustion.—Bath A can be used repeatedly without appreciable change, taking at least eighteen 36-exposure strips of 35-mm. film (900 sq. in. of negative) per half-litre (17½ oz.) before rate of development or emulsion speed changes seriously. Bath B deteriorates more rapidly, the extent of deterioration depending on the amount of A carried over. For tank work, probably three strips (150 sq. in. of negative) would represent the desirable limit of use.

Grain.—Owing to the low alkalinity of bath A, and the fact that grain is most noticeable in the lighter half-tones, grain is slightly better than that given by D.76.

Emulsion Speed.—Claimed to be even a fraction higher than with D.76—and is quite certainly no lower.

Meritol-Caustic.—A two-bath developer in which practically no development takes place in the first bath, so giving an enhanced "two-bath effect," with full development of shadow detail and heavily curtailed development of the highlights. It is particularly valuable for stage scenes and other subjects of exceptionally high contrast. As the extent of development is almost entirely controlled by the quantity of developing agent carried over in the film into the second bath, the only useful control of overall contrast is by the variation of concentration of Meritol in the first bath.

For an average film, the following is suitable :—

A.	Meritol	60 gr.	(7 gm.)
	Sod. sulphite (anhydr.) .	350 gr.	(40 gm.)
	Water to . . .	20 oz.	(1000 c.c.)
B.	Caustic soda, 10% . .	1¼ oz.	(40 c.c.)
	Water to . . .	16 oz.	(500 c.c.)

The proportions of the B bath are by no means critical.

For a slow-developing film, the quantity of Meritol may be increased to 90 gr. (10 gm.), or for a more rapidly developing film, it may be reduced to 45 gr. (5 gm.).

The film is immersed in A for 3 minutes at 65° F., and then, without washing, transferred to B for 2 to 3 minutes, and thence to a hardening stop-bath (*q.v.*).

The B bath must be made up at the time of use, and discarded the same day. The A bath may be kept in use for prolonged periods.

Grain.—Not very fine : may be coarser than D.76.

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Emulsion Speed.—Considerable increase in speed has been claimed, but not fully substantiated. Except perhaps at low values of gamma, the speed probably does not exceed that obtained with D.76. It should be noted that Meritol-caustic very greatly reduces the exposure-latitude of the film, and with some films may give rise to dichroic fog.

PHYSICAL DEVELOPMENT.

In the ordinary process of "chemical" or "alkaline" development, the silver forming the image is derived from the silver compounds present in the emulsion itself (see DEVELOPMENT). In physical development, on the other hand, the silver is deposited from the developing solution.

The developer consists of a solution containing a silver salt and a reducing agent, and is so balanced that silver is just on the verge of being thrown down. If this solution is brought into contact in suitable conditions with an exposed film, the silver is preferentially deposited on the parts of the film that have been acted on by light. The grain of an image so formed is exceptionally fine, as the tendency for the grains to "clump" is much smaller than in chemical development.

In early efforts at physical development it was found that very full exposure (up to five or ten times normal) was needed, but Dr. A. F. Odell, of America, found that by giving the film a preliminary treatment with potassium iodide solution this extra exposure was no longer needed. His methods have since been modified a little by the late P. K. Turner, the leading English exponent of physical development, and full working data can be found in his book, *Processing Miniature Films*.

Finger-Print Photography. The great use to which photographs of finger-prints have been put in many important cases has caused a considerable amount of attention to be devoted to this branch of work. The criminal investigation departments of most countries are now equipped with every facility for making finger-print records of criminals and "suspects," and for producing photographic enlargements for reference. The taking of a photograph of a faint impression of a finger on some object touched by a criminal or other person is an undertaking requiring considerable technical knowledge. The following methods will be of service when photographing finger-prints made upon different surfaces:—

(*a*) On light surfaces such as china plates; dust on (dry) very fine graphite powder; blow off with bellows, etc., *not*

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with breath. The " dusting-on " is best effected by charging a heavy, flat-ended camel's-hair brush with the powder, holding it near the surface and jerking it by a blow on the hand which is holding it.

(*b*) On dark surfaces, such as the black or green paint of a safe, mahogany furniture, etc.; treat similarly, using fine, dry white-lead powder.

(*c*) " Invisible " finger-prints on paper. Develop with aqueous solution of silver nitrate (5 to 8 per cent.).

A useful work including the subject of finger-print photography is *Photography and Crime Detection*, by Radley (Chapman and Hall).

Fingers, Stains on, To Remove. See SKIN, EFFECTS OF CHEMICALS ON.

Finishing Prints. See BROMIDE PAPER, SPOTTING PRINTS and DOPE. Also COLOURING PHOTOGRAPHS and AIR BRUSH.

Fixatif, or Varnish for Prints. See VARNISH.

Fixed Focus. Term applied to cameras (or lenses) devoid of focusing adjustment. As any such camera may be called upon to produce photographs of either views or groups, the focusing is actually set by the makers at the hyperfocal distance (*q.v.*). Objects are then sufficiently sharp from half this distance to the horizon. A fixed setting such as this is only satisfactory in practice when the hyperfocal distance is small enough for it to be unlikely that the user of the camera would wish to approach more nearly to his subject than half this distance.

A small hyperfocal distance requires either a small stop or a short focal length, or both. Fixed focus is therefore mainly restricted (*a*) to cheap cameras, usually of box type, in which the aperture of the lens is about *f*/14, (*b*) to inexpensive miniature cameras using a lens of focal length round about 2 in., and having an aperture up to about *f*/6, and (*c*) to cine cameras, in which the focal length of the lens may be as little as half an inch (8 mm. size). In the last case a very large stop may be used with satisfaction. With 16 mm. cameras a fixed focus lens is generally used for lenses of maximum aperture up to *f*/3·5, but for faster lenses a focusing movement is in most cases fitted.

For formula and further details, see HYPERFOCAL DISTANCE.

Fixed-Focus Telephoto Lens.—In this special case the term " fixed focus " does *not* mean that the lens cannot be focused,

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but that it has one unalterable focal length, and cannot be adjusted to give varying degrees of magnification. (See TELEPHOTO LENS.)

Fixing. The removal of any sensitive substance not acted upon by light or by the developer, thus rendering the negative or print unalterable by further action of light. For all negatives, and for prints on paper the sensitivity of which is due to compounds of silver, the fixing agent invariably used is a solution of sodium thiosulphate, familiarly known to all photographers as "hypo." This universal term is an abbreviation of "hyposulphite of soda," the name by which hypo was known in a now long obsolete system of chemical nomenclature. The newer rapid fixers are made from the closely-related ammonium thiosulphate; these are proprietary preparations of undisclosed formula, and should be used according to the maker's instructions. What follows refers specifically to ordinary hypo.

Fixing is carried out by leaving the developed print or negative in a solution of hypo of concentration about 20 per cent., or 4 oz. to the pint, until all silver compounds are dissolved away, or, more correctly, converted into soluble compounds that can be removed in the subsequent washing. To prevent staining due to the oxidation of developer, it is now almost invariable practice to add an acid to the bath. As hypo is very readily decomposed by any but a weak acid, sulphurous acid, either in the form of an acidified solution of sodium sulphite, or as bisulphite or metabisulphite, is employed. An addition of potassium metabisulphite to the extent of about $2\frac{1}{2}$ per cent. ($\frac{1}{2}$ oz. per 20 oz.) is usual (see ACID FIXING). It should be noted that for print-out papers, including self-toning papers, the fixing bath must *not* be acid; a 10 per cent. solution of hypo to which is added a few drops of ammonia or a pinch of sodium bicarbonate is desirable for these papers.

The strength of the hypo-bath is not critical; since the action proceeds to completion in any case, a weaker bath may be used provided longer time is allowed for its action. Too strong a bath, however, is not advised; it leads rather readily to reticulation, frilling, and other damage to the gelatine, and offers but little compensation as regards quicker fixing.

In the U.S.A. a hardening fixing bath, containing chrome or potash alum as the hardening agent, is now almost universally used for all purposes. Chrome alum baths are inconvenient, for they lose their hardening properties rapidly

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on standing, whether used or unused. Potash alum baths have the disadvantage that their use greatly increases the retention of hypo by the film, particularly in the case of negatives. This effect can be reduced by keeping the acidity of the bath low, in which case the hardening power is speedily lost and the bath may deposit a sludge in use. With prints this effect is not important, but with negatives the use of a potash alum bath of high acidity (pH$=4{\cdot}1$) may increase the necessary washing period by as much as nine times as compared with a simple acid fixer of pH$=5{\cdot}6$. (See also HARDENING FIXER.)

Although an alkaline or neutral fixing bath does not attack the image unless air has access to the print or negative at the same time, if part of a negative is allowed to project above the surface of the hypo solution, all the exposed part will be reduced, the reduction being greatest along the line marked out by the surface of the liquid. Any acid fixing bath, however, will tend to attack the image if immersion is prolonged beyond the time strictly necessary for adequate fixation, the reduction being most noticeable in the lighter parts of the image. In an exceptional case, these may disappear altogether in half an hour or so, especially if the image is of very fine grain. Special care should, therefore, be taken in connection with fine-grain films and with fine-grained (warm-tone) images on printing paper.

Hypo dissolves rather slowly in cold water, and cools the water considerably in the process. As it is not decomposed by heat, the solution is best made by pouring hot water, in which it dissolves very rapidly, straight on to the crystals. The cooling that accompanies solution enables the bath to be ready for use in a very short time.

Fixing Negatives.—Fixation is not complete for some few minutes after the negative has become clear and free from the milky appearance that shows the presence of unused silver salts. The old rule that it should be left in the bath for a total time twice as long as it takes to clear is a good guide, though in a fresh bath it will be fixed before this, and in a stale bath, though it may clear, it may never be fully fixed however long it is left. All valuable negatives should be given a few minutes in a second, unused, hypo bath before being put to wash.

Fixing Prints.—It has been shown that a bromide print is fully fixed within 30 seconds if kept moving in perfectly fresh hypo. On the other hand, if a pile of prints is put in so that

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the solution cannot circulate between them, they may never fix at all. It is therefore meaningless to state a time for fixation unless the details of handling are also specified. In practice, if a print is turned over and over in the hypo for some 15 seconds, and then left for a few minutes, during which it is brought into contact with fresh solution two or three times by turning over the pile of prints one by one, it may be regarded as being as fully fixed as the condition of the hypo-bath will allow.

Exhaustion of Fixer.

After it has fixed a few prints, a hypo-bath becomes loaded with the silver it has taken up, and though it remains capable of dissolving out the bulk of the silver from any new print put into it, it can no longer take out quite all. A pint (20 oz.) of fixing bath should never be called upon to fix more than an absolute maximum of 300 sq. in. of film (equivalent to four 8-exposure 2¼ × 3¼ spools) or 360 sq. in. of paper (11 or 12 half-plate prints); even after only this amount of use, the residual silver will be readily detectable, and will lead to tinting of the whites in prints that are sulphide toned. Where the highest standard of permanence is required, as for permanent records, the area of sensitive material fixed must be drastically cut down; each pint of fixer should then not be called upon to fix more than 24 sq. in. of film (three 2¼ × 3¼ negatives); for an 8-exposure spool at least 60 oz. of fixer should be used, and then discarded. For prints of the same standard of permanence, only 60 sq. in. (two half-plate prints) may be fixed in each pint.

Two-Bath Fixing.

Complete elimination of the silver salts can be much more economically attained by keeping the fixer in use very much longer than the above figures suggest, and then backing it up with a second, fresh, bath which is still capable of removing the last traces of silver. This bath, receiving only prints already freed of most of their silver, can be used for a good many films or prints, and when no longer fresh enough to carry fixation to completion may very well be used as the first bath.

Working in this way, a pint (20 oz.) of the first bath can fix, as a maximum, 800 sq. in. of film (ten or eleven 8-exposure, 2¼ × 3¼ spools) or 1600 sq. in. of paper (50 to 55 half-plate prints), or, for the highest permanence, up to 480 sq. in. of film (six 8-exposure 2¼ × 3¼ spools) or 840 sq. in. of paper

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(27 half-plate prints). After this amount of use it should be discarded, and the second bath moved up into its place; the amount of work this has already done is too small to affect the work it can do in its new role of first bath. A second bath of fresh hypo is of course brought into use.

As, however, there is a slow accumulation of silver in baths used in this way, the fifth second bath should *not* be moved up to become the next first bath, but both should be discarded and the cycle re-started with fresh solution for both baths.

Working in this way, the highest permanence is assured with an expenditure of hypo of little more than half that needed for just-passable fixation by the single bath method. To avoid the possibility of the image being attacked, and, where a hardener is used, to shorten washing times, the second bath should only be acidified, or have its hardener added, when it is moved up to take the place of the first bath.

Test for Exhaustion.

A hypo-bath may be tested for exhaustion in several ways, of which the simplest is to add 1 part of a 4 per cent. solution of potassium iodide to 10 parts of the used hypo bath. If there is formed a permanent yellow precipitate that will not dissolve on shaking, the bath contains too much silver to be capable of properly fixing either negatives or prints.

(See Acid Fixing Bath and Rapid Processing; also Hypo Eliminator, Sodium Thiosulphate, and Solutions, Making Up.)

Flare. A fogged patch, generally circular or arch-shaped, on a developed plate. It is due to reflections within the lens by which an out-of-focus image of a naked light or other brilliant high-light is formed. The resulting patch of fog is more usually at an equal distance from the centre of the negative, but on the opposite side. Often, however, flare may result from a light not actually included in the picture. It may take the form of a secondary image of the light itself, or may be an image of the diaphragm or part of the lens mount. With a coated lens (*q.v.*), flare is unlikely to make its appearance except under the most difficult conditions.

Flare not due to the design of the lens may sometimes arise from reflections at the edges of the mount or of the diaphragm if these have worn bright.

See also *Examination of Lenses*, under Lens.

Flashbulb. A glass bulb containing an inflammable material the burning of which can be initiated, so producing

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a brilliant momentary light, by passing an electric current through a fine fusible filament. On the supports of the filament are blobs of dried paste, in appearance and behaviour not unlike the head of a match; when the filament fuses this paste flares up and scatters through the rest of the bulb, which is filled with foil or fine wires of a magnesium-aluminium alloy, or of zirconium, in an atmosphere of oxygen. The flying white-hot paste sets this foil or wire on fire at numerous points in the bulb, and it burns rapidly giving an intense flash.

As can be seen, the production of the flash follows a brief period after the closing of the electric circuit to fuse the filament; in almost all modern flashbulbs the delay is standardized at 20 milliseconds from closing the circuit to the peak of the flash. The duration of the flash depends on the size and design of the flashbulb; with the smallest bulb it is about 8 milliseconds, but the special focal-plane bulbs are designed to give a more or less constant output of light over a period that may be as much as 45 milliseconds.

At one time small bulbs, under the name Speed Midgets, were made; these contained no wire or foil, but derived their light entirely from an extra-large proportion of the explosive paste. This enabled the peak output to be reached in about the time that it takes an average shutter to open, so simplifying synchronization of shutter and flash. These bulbs, however, proved unsatisfactory in use and are no longer sold in Britain.

For the practical use of flashbulbs, see FLASHBULBS, EXPOSURES WITH, and FLASHGUN.

Flashbulbs, Exposures with. With an " open " flash, using a simple synchroniser or opening the shutter by hand just before firing the bulb, all the light emitted by the bulb is used and the duration of the flash itself determines the time of exposure. It remains in this case to adjust the stop to suit the distance of the flash from the subject and the speed of the film in use.

When using a flash in conjunction with a fairly high shutter-speed, only part of the flash is used, and the stop required depends on the shutter-speed in use. It is always larger than is needed for an " open " flash.

In flash photography, exposures are always calculated with the aid of a flash-factor or guide-number. This is a figure, normally derived from the instructions accompanying the flashbulb, which depends on the size of the bulb, the speed of film in use, and (where this arises) on the speed to which

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the shutter is set. These factors being fixed, there remain to be considered flash-to-subject distance (in feet) and the aperture of the lens; the product of these two is the guide-number. If, therefore, the guide-number for the bulb and film in use is quoted as 160, then if the distance between the bulb and object is 10 feet, correct exposure is obtained if the lens is set to *f*/16.

Except for the focal-plane bulbs, flash duration is seldom longer than 1/50 sec., so for this and all slower speeds the full light output of the bulb is used. For such cases the guide-number can be calculated from the formula $F = 0{\cdot}18\sqrt{LW}$, when L is the total output of the bulb in lumen-seconds and W is the A.S.A. speed of the film in use. Thus for a flashbulb of output 10,000 lumen seconds, used with a film of speed 64 A.S.A., $F = 0{\cdot}18\sqrt{640{,}000} = 0{\cdot}18 \times 800 = 145$ approx. This formula assumes a reflector-factor of 6, which implies a reflector of good efficiency. Guide-numbers calculated from the formula, or taken from manufacturer's literature, should be regarded as being no more than a starting-point for experiment, for the practical guide-number can vary over a range of nearly three to one (an eight-to-one ratio of exposure) according to the characteristics of the reflector with which the bulb is used. It can also depend very greatly on the amount of light reflected back on to the subject from its surroundings, and on the depth of tone of the subject itself.

It is not possible to calculate guide-numbers for shutter-speeds high enough to include part only of the flash except by taking into consideration the time-light curve of the particular bulb to be used. (L in the above formula then becomes the lumen-seconds output during the time for which the shutter is open). If, however, experiment shows that it is desirable to take half the manufacturer's guide-number when working at 1/50 sec. or slower, it should be perfectly safe also to halve manufacturer's figures for higher shutter speeds.

Flashed Opal.—Glass the body of which is clear, but of which one surface has opal (porcelain-like) characteristics. Used as a diffuser in enlargers and for similar work. True opal glass ("pot opal"), which is of porcelain-like character throughout its whole mass, absorbs very much more light than flashed opal.

Flashgun. As applied to work with flashbulbs (but see also ELECTRONIC FLASH), an accessory consisting of a casing

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on the outside of which is a reflector and a socket for the bulb, and which contains a battery or battery-capacitor system for providing the electrical energy required to fire the bulb. In most cases the flashgun is intended to be attached to the accessory shoe of the camera or to a bar screwed to the tripod bush, and a lead to connect it to the synchronizing socket of the shutter is normally supplied. (But see EXTENSION FLASH.)

The simple flashgun, of circuit as depicted in Fig. 1 and firing the bulb by connecting it directly to a 3-volt battery, is now nearly obsolete, having been replaced by the battery-capacitor gun of which the circuit is shown in Fig. 2. Instead of relying,

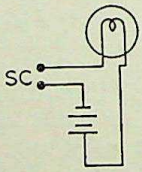

FIG. 1.

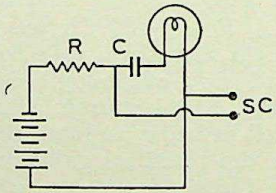

FIG. 2.

as in Fig. 1, on the battery's ability to drive a very heavy, if only momentary, current through the bulb, the tiny 22½v. hearing-aid battery of Fig. 2 charges the capacitor C (usually 100 mfd.) through the filament of the bulb and the resistance R (usually 2500 ohms or so); the charging time is three or four seconds at most, and it does not matter in the least if the battery is old or in poor condition—this only lengthens the charging time by a few seconds. When the shutter contacts S.C. are closed, the energy accumulated in the capacitor is discharged through the bulb in about one-thousandth of a second, so immediately fusing the filament and initiating the firing of the bulb. This gives reliable synchronization of flash to shutter, and allows the battery a very long life—in amateur hands, usually about a year, even with considerable use.

Synchronization.—In modern practice the contacts (S.C., Fig. 2), the closing of which has to be so timed as to ensure that the flash fires during the period that the shutter is open, are included in the between-lens shutter itself. A shutter so equipped is known as a " synchronized shutter," and carries

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on its body a small circular socket, with concentric contacts, into which the plug attached to the flashgun is inserted.

In the simpler synchronized shutters, contact is made just as the blades reach the full-open position (X-synchronization), for this is the only setting suitable for electronic flash, which fires with virtually no delay. Flashbulbs can equally well be used, provided the shutter is kept open long enough to give the flash time to develop. In practice this means that the shutter must be set to a speed not higher than 1/30 sec. when using a wire-filled (M class) bulb.

To obtain exact synchronization at higher speeds with M-class bulbs, of delay 20 milliseconds to peak output, it is necessary to close the firing contacts some 15 to 18 ms. before the shutter begins to open. This calls for a special delay clockwork, which closes the contacts as soon as depression of the shutter-release starts it, and releases the actual blades of the shutter at the end of its run 15 ms. later. Such extra mechanism is fitted only to the more expensive shutters, and these always have an adjustment permitting choice between X and M synchronization. At the M setting, M-class bulbs can be used in conjunction with all shutter speeds, but electronic flash cannot be used at all, as the flash would be over before the shutter opened. For this the shutter is set to " X ".

Synchronization of flash to focal-plane shutters is very much more complex, and can be approached in either of two ways. The simpler is to set the shutter to a slow speed (usually 1/25 sec.) and to time the flash so that it fires when the whole area of the film is uncovered. This is the only method practicable with electronic flash and the smaller M-class bulbs.

For synchronization at the higher shutter speeds a special " long-flash " bulb is needed to maintain approximately constant light output during the whole time of travel of the slit over the film. This is fairly easily achieved with small cameras, where the time of travel of the blind is only some 20 to 25 milliseconds (with these shutters one or two of the larger M-class bulbs can be used) but requires very exact synchronization with larger cameras (*e.g.*, 9 × 12 cm.) where the total time of exposure, even with the shutter set to 1/1000th sec., may be 30 to 40 milliseconds or even more.

Lighting. The simplest method of lighting the subject is to use a single bulb in the holder of the flashgun itself. As this is usually attached to the camera, the lighting tends to be flat. By means of an extension wire, the bulb can be fired

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from a point away from the camera, but this tends to give extremely heavy shadows unless there is a light-coloured wall or other reflecting surface near the object. It is, therefore, often found best to use a second bulb, fired at the same time as the first, to illuminate these shadows. (See EXTENSION FLASH.)

Synchro-Sunlight Photography.—The technique of using flash to supplement daylight. In most typical cases, the flash is used on the camera as a "fill-in" light when photographing a close-up subject back-lit, or strongly side-lit, by direct sunlight. The main difficulty in this work is balancing flash against the sunlight, for if the flash is too weak its contribution will be negligible, and if it is too strong the subject stands out unnaturally light against an over-dark background and all feeling of sunlight is lost.

Experience is most desirable, but a reasonable approach to good balance can be had thus. Work out the stop to be used by the application of the guide-number in the usual way (see FLASHBULBS, EXPOSURES WITH), but set the lens to an aperture two stops smaller than that found. This smaller stop is used because, at the normally calculated stop, the subject would be fully exposed by the flash alone. Using the exposure-meter, find what shutter-speed would be required, in the absence of the flash, in conjunction with the stop to which the lens has been set. As, at this shutter-speed, the exposure-meter is making allowance for fairly deep shadows, which will in fact be filled in by the flash, double the indicated shutter speed (*i.e.*, 1/100 in place of 1/50) should be used.

For fuller information, refer to *Photoflash in Practice*, by Geoffrey Gilbert.

Flashlight.—General term for illumination provided by the rapid combustion of flashpowder (*q.v.*) or of the contents of a flashbulb (*q.v.*). Applied also to the light produced by the very rapid discharge of a condenser through a bulb containing a gas. (See ELECTRONIC FLASH.)

Flashpowder.—A powder burning rapidly and giving a brilliant light during combustion. Used as an "instantaneous" source of artificial light, the technique of use being that of the "open flash," where the shutter is first opened, the flash is next fired, and finally the shutter is closed again. The duration of the exposure is equal to the duration of the flash.

A flashpowder is a mixture of magnesium (or aluminium) with another substance that provides the oxygen necessary

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for combustion. The mixture is explosive, and requires handling with considerable care, though it is not in the least dangerous if intelligent precautions are taken. It is usually fired by means of a flash-lamp, in which the powder is held on a metal tray and ignited by a spark, an electric current, or by a fuse of guncotton, gunpowder, or touch-paper.

Quantities of flashpowder or magnesium required.—The following table has been calculated from figures given in the "Ilford Manual." The quantities apply for a stop of *f*/5·6 or *f*/6·3 and a film of speed about 100 A.S.A. They are correct for a fairly light room with walls not too far from the subject, and the proportional amount increases with distance to allow for the probable recession of reflecting surfaces. In the open, quantities should be at least doubled. When using pure magnesium (not a mixed powder) about half the quantities given will be required. Ribbon may be calculated by length; of the ordinary ribbon, $\frac{1}{12}$ in. wide, 5 in. weigh about 1 gr., or 20 cm. weigh about $\frac{1}{10}$ of a gram.

The output of light given by a flashpowder is approximately 100,000 lumen-seconds per grain of magnesium.

TABLE GIVING QUANTITIES OF FLASHPOWDER

Distance of Subject from Flash.		Amount of Flashpowder required.	
Feet.	Metres.	Grains.	Grams.
6	1·8	1	0·06
8	2·5	1½	0·1
10	3	2½	0·16
12½	3·8	4	0·25
15	4·5	6	0·4
17½	5·3	8	0·6
20	6	12	0·8
25	7·5	20	1·3
30	9	30	2·0
40	12	55	3·5
50	15	90	6·0

(See also MAGNESIUM and SILHOUETTES, PHOTOGRAPHIC.)

Flatness. A want of vigour and contrast in the negative and resulting prints, due to extreme under- or over-exposure,

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to under-development, or to fog. (See DEVELOPMENT and SENSITOMETRY.)

Flexichrome. A Kodak process for the production of prints and transparencies in full colour from a monochrome original by applying dyes to a relief image in gelatine. The process is completely different from the tinting or colouring of a silver print, because the final image is composed entirely of dyes, which are absorbed by the gelatine relief in proportion to the depth of the image. Materials for this process are no longer made.

Fluorescence. See RADIOGRAPHY.

Fluorescent Lighting.—The recently-introduced fluorescent lamps are attractive to photographers on account of their high luminous efficiency—that is, because they give more light per unit of electrical power consumed than do any other lamps of comparable life. Their output of light is about 35 lumens per watt, or over double that of an ordinary half-watt lamp.

These lamps take the form of long tubes filled with mercury vapour at low pressure, and the ultra-violet light produced by the electrical discharge through this is converted into visible light by the fluorescent properties of the compounds with which the inside of the tube is coated. When alight, these lamps give an even glow throughout their length, and owing to their large surface the intrinsic brilliance is low, so that dazzle is avoided.

These characteristics make fluorescent tubes ideal for general lighting in portraiture, copying, and similar work, but they are less desirable where directed light is required, and of course cannot be used in a spotlight.

A point requiring special attention is that the light from these lamps rises and falls in time with the alternations of the electric current supply, successive maxima of brightness occurring at intervals of 10 milliseconds. When using a diaphragm shutter this is of no importance, but it may lead to bands of uneven density on a negative exposed with a focal-plane shutter.

It should also be noticed that the spectrum of the light emitted is a discontinuous one, so that it cannot properly be said to have any definite colour-temperature. The use of these lamps for colour photography should therefore be approached with caution.

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Fluorography.—Term applied to the photography, usually with a miniature camera, of a fluorescent screen on which is cast, by X-rays, a shadow image of some object placed between the source of X-rays and the screen. Preliminary examinations, for tuberculosis and other lung troubles, of large bodies of workpeople have been carried out in this way.

F-Numbers. See DIAPHRAGMS.

Focal Length, Focus, Equivalent Focal Length. The focal length, or equivalent focal length, of a lens is defined as the distance from the node of emission (see LENS), to the position at which the lens forms a sharp image of a distant object. The scale of the image is proportional to the focal length; if one lens has a focal length twice that of another, the sizes of the images of a distant object will also be in the ratio of two to one in linear dimensions.

The *focus*, or principal focus, of a lens is a point on the axis at which the image of a distant point, also on the axis of the lens, is formed. The term "focus" is, however, often used as a shorter synonym for "focal length," especially when speaking of a "short-focus" or "long-focus" lens.

Finding Focal Length.—The focal length of most modern lenses is engraved upon them, but the engraved figure is usually only nominal, and may be in error by up to four per cent. This is a limit set by British Standard 1019/1949, but is probably exceeded in some cases. If an exact figure is required, the most direct procedure is to locate the node of emission, and then measure the distance between it and the image of an object at infinity.

For this, set up the lens, with its axis horizontal, on a support so mounted that it can rotate about a vertical pivot, arranging that the lens can be moved axially so that any part of it can be brought above the pivot. By trial and error, find a position of the lens such that the sharp image of a distant object does not move when the lens is turned slightly from side to side on the pivot. The node of emission of the lens is then exactly over the pivot, and the horizontal distance from this to the sharp image of a distant object is equal to the true focal length.

Second Method.—Fit the lens to a long-extension camera, focus a distant object, and mark the camera extension. Then focus sharply on a near object (preferably a ruler) and note, by

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holding a second ruler against the screen, the exact scale of the image. Note also the extension of the camera beyond the infinity position already found. If the linear scale of the image is 1/*n*th of that of the object, and the extra extension is x, the true focal length of the lens is nx. The most accurate results are obtained by focusing the ruler at a little less than life size.

Third Method.—If the camera will not focus near objects, and has no focusing screen, set up the camera at 7 to 10 feet from an object of measured length, focus it sharply and photograph it. Measure the exact distance of the object from the lens. On the negative, carefully measure the length of the image. If the length of the object is n times that of its image, and the distance between lens and object is D, then :

If focusing has been done by moving the lens bodily away from the film, the focal length is equal to $D \div (n+1)$.

If focusing has been done by a rotating front cell, or by attaching a supplementary lens, the focal length, when focused on infinity, is equal to $D \div n$.

This method is not strictly accurate unless D is measured from the node of the lens ; except with telephoto lenses, however, the error will be negligibly small if the measurement is made from the iris diaphragm.

With a telephoto lens, photograph the test object at two known distances D_1 and D_2 from any arbitrary point on the lens, and find the scales of reduction, n_1 and n_2, of the resulting images. The true focal length is then $(D_1 - D_2) \div (n_1 - n_2)$. This applies irrespective of the method of focusing used.

Fourth Method.—Point front of lens at a distant object. Measure the distance a of image from some fixed point P on the lens. Point back of lens at a distant object, and measure distance b of image from some fixed point Q on the lens. Place an object at about two focal lengths from front of lens, and measure its distance c from point Q. Finally measure distance d of the image of c from point P.

Then $f^2 = (d—a)\ (c—b)$. This is precise, and in most cases will be found the easiest method to apply.

Depth of Focus and *Conjugate Foci* are discussed under their respective headings.

Focal-Plane Shutters. See SHUTTER, also MOVING OBJECTS.

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Focal Plane, The. The plane in which the image formed by the lens is sharp.

Focus. Point on the optical axis to which a lens converges light parallel to that axis. See also FOCAL LENGTH.

Focus, Depth of. Strictly, the variation in the lens-to-film distance that can be permitted without incurring a loss of sharpness too great to be acceptable. More generally used, in place of the correct term "depth of field," to indicate permissible variation in subject-to-camera distance. See *The Accuracy Required* under FOCUSING SCALE and also DEPTH OF FOCUS.

Focusing. The operation of so setting the camera or lens as to ensure sharpness in the image of those parts of the subject required to be sharply rendered.

Methods of Focusing.—The oldest method of focusing, which by many is still considered the most satisfactory, is by adjusting the distance between lens and sensitive surface. A method now quite common is that of "front-cell focusing," in which the separation between the back of the lens and the sensitive surface is left fixed, and the focal length of the lens is shortened by screwing out the front glass (or combination). The mechanical simplicity offered by this scheme is heavily in its favour. For close-up subjects with fixed-extension cameras, focusing is done by the addition of "magnifiers" or positive supplementary lenses, which again shorten suitably the focal length of the lens. (See SUPPLEMENTARY LENS.)

Rack and Pinion Focusing.—Where the lens-panel is carried on an inner baseboard that can be moved relatively to the main baseboard to which the carrier for the plate or film is attached, as in most double-extension cameras, it is usual to provide a rack and pinion for controlling the movement of the inner baseboard. The front of many reflex cameras is also carried on racks, and is moved in and out for focusing by pinions turned by the focusing knob. Though rather coarse, this type of focusing allows a wide range of movement to be covered satisfactorily.

Lever Focusing.—Is sometimes applied to single-extension cameras in which the lens-panel as a whole moves forward for focusing; a considerable movement of the lever usually corresponds to a comparatively small movement of the lens-front.

Focusing by Helical Mount (*Focusing Mount*).—In many fixed-extension cameras, notably focal-plane (Press) cameras

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and those miniature cameras which follow them in fundamental design, the lens is in a screw mount, by turning which it can be moved bodily forward by a sufficient amount for focusing ordinary subjects. (Distance not less than 3 ft. in some models, 5 or even 7 ft. in others). Since the scale is on the lens-mount itself, this type of focusing necessitates an accurate adjustment of the distance from lens-flange to sensitive surface. With the ordinary focusing mount the lens turns as it moves forward; in a *rectilinear focusing mount* it does not. The latter, though less often seen, is preferable when a graduated filter (*q.v.*) or a lens-hood of non-circular form is in use, or when the shutter has to move forward with the lens.

Front-cell Focusing.—This method, described above, is now used in a good many simple cameras.

Ensuring Sharp Focus.—Except for special purposes, the camera which relied on visual focusing on a screen at the back of the camera is now defunct. Reflex cameras are visually focused, using an image thrown, *via* a mirror, on to a screen at the top of the camera. In a single-lens reflex, the lens used is that which will take the picture; in a twin-lens reflex, a second lens matched to the taking lens is used. Most cameras rely on *scale focusing* (see FOCUSING SCALE) in which the lens is adjusted by setting a pointer to a figure indicating the distance of the principal object. This distance may be estimated, or it may be measured by a foot-rule or by optical means (see RANGE FINDER). The term *range-finder focusing* is usually applied only to those cases where the camera has a "coupled" range finder, so built that adjusting it to a given distance simultaneously focuses the lens on that distance. The term *automatic focusing* is occasionally used to describe cameras so equipped. (See FOCUSING SCALE, RANGE FINDER, REFLEX CAMERA, DEPTH OF FOCUS, HYPERFOCAL DISTANCE, FIXED FOCUS, DIAPHRAGMS, etc.)

Focusing Cloth. A piece of black or red material, about a yard square, placed over the head and shoulders of the photographer and the back of the camera to exclude extraneous light when examining the image on the focusing screen of a stand camera.

Focusing Glass, Focuser, or Focusing Magnifier. A small magnifying eye-piece, used to obtain microscopic sharpness of focus upon the ground-glass. Fitted as standard in the hood of all small reflex cameras.

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Focusing Mount. Mount in which the lens is moved bodily forward by a screw thread for focusing. (See FOCUSING, FOCUSING SCALE.)

Focusing Scale. In all methods of focusing a forward movement of some part of the lens or camera is involved. A pointer on either fixed or moving member indicates, on a scale attached to the other, the distance on which the lens is focused at its various positions. A scale may be marked in feet, yards, or metres, the latter being used on cameras made for the Continental market. Most cameras for the English market are scaled in feet.

Generally the distances marked on the scale are arbitrarily selected. A logical scale can be constructed by marking first infinity, next the hyperfocal distance, then integral submultiples (half, third, quarter, fifth, etc.), of the latter. (See DEPTH OF FOCUS for the advantage of this system.)

The Accuracy Required.—If the lens (or the film) is displaced by a distance δ from the point of true focus, an image that should be a point will blur out into a circle of confusion (*q.v.*) of diameter c, the relationship between the two being approximately $\delta = nc$, where n is the f-number of the stop in use. If c is allowed to rise to a value of about one-twelve-hundredth of the focal length of the lens, the image will be just noticeably unsharp, so that it is safe to say that the absolute maximum of error in lens-to-film distance that can be permitted is $nf \div 1200$, where f is the focal length of the lens. Thus with an $f/3{\cdot}5$ lens of focal length $4\frac{1}{4}$ in., the scale requires to be set and read with an accuracy of practically one-hundredth of an inch if sharp pictures are to be relied upon. With the 2-inch $f/2$ lens not uncommon on miniatures, an error of about one three-hundredth of an inch will be sufficient to destroy sharpness.

With rack and pinion focusing, in which the actual movement of the lens, unmagnified, has to be followed on the scale, considerable difficulty is found in marking or reading the scale with sufficient closeness. With lever focusing the position is somewhat eased, and where a focusing mount or front-cell focusing is used the peripheral movement is usually large compared with the forward movement. Using a mount which focuses to 5 ft. with a rotation of 320°, a forward movement of a hundredth of an inch is indicated by a movement of 10°, corresponding on a mount of 1-in. radius to a scale-movement of nearly a quarter of an inch. This type of scale

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can therefore readily be adjusted with all the accuracy needed, even with ultra-fast lenses. It is easy to see why the rotary type of scale is almost universally used.

Marking out a Scale.

The following formula will enable a focusing scale to be constructed for any lens the focal length of which is known.

If f = focal length of lens.

u = distance of object focused upon.

d = distance, from the " Inf." setting, that the lens must move forward to focus on u, then

$$d = \frac{f^2}{u - f}$$

Units must be the same for all three quantities.

Example.—How far must a 3-in. lens be moved forward from " Inf." to focus on 20 ft. ?

Here $f = 3$ in., $u = 20 \times 12 = 240$ in.

Therefore $d = \frac{3 \times 3}{237} = 0{\cdot}038$ in.

This figure is for actual lens-movement ; if it is in a focusing mount so constructed that one inch of movement of the pointer round the scale corresponds to a tenth of an inch forward movement of the lens, it is evident that the position of the pointer when focused on 20 ft. will be 0·38 in. from the " Inf." mark. By carrying out the above simple calculation for a series of distances a complete focusing scale can be constructed.

Note, however, that the formula pre-supposes an *exact* knowledge of the focal length of the lens. Engraved figures are often merely nominal, and not to be relied upon for constructing a scale. Either the focal length must be accurately determined (see FOCAL LENGTH) or else the scale must be constructed, as shown below, from the experimental determination of two focusing-points.

Filling in a Scale.—Where a camera already has a scale, but the distances marked are too widely spaced, or do not include certain distances (*e.g.*, the hyperfocal distance), for which a specific mark is required, it is easiest to calculate the new distances from those already marked. The same procedure can be used to construct a complete scale if the focusing settings for two distances, conveniently infinity and one near distance, are first found by careful experiment.

From the formula above it is evident that the product $d(u-f)$ is the same (for any one lens) for all focusing distances,

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and it is also clear that a small error in the value of f will lead to only a negligible error in the product. Suppose that the infinity point and the setting for 5 ft. are known. The distance between them (d) may be measured in inches or millimetres along or round the scale, or, in the more usual case of a rotary scale, in degrees of rotation. If in turning the mount of a 3-inch lens from " Inf." to 5 ft., it rotates through 180°, then $(u-f) = (60-3) = 57$ in., and $d(u-f) = 180 \times 57 = 10{,}260$. To find the setting, in degrees from the Infinity point, for any other distance, subtract the focal length from the distance in question (in inches) and divide the result into 10,260. For 20 ft., therefore, the setting would be $10{,}260 \div (240-3) = 43{\cdot}3$ degrees; for 3 ft., it would be $10{,}260 \div (36-3) = 310{\cdot}9$ degrees.

It will be observed that in this procedure the relationship between rotation of the mount and its forward movement does not enter. This is desirable, as the relationship is not usually easy to measure with any accuracy.

For further details, refer to " Re-scaling a Miniature " (*Amateur Photographer*, October 14th and 21st, 1942).

The above procedure applies when focusing is done by moving the whole lens forward; with front-cell focusing du, in place of $d(u-f)$, is constant, or nearly so.

Focusing Scale for Close-ups.—The calculation of the distances actually focused upon at various settings of the scale when using a supplementary lens will be found under SUPPLEMENTARY LENS.

Checking a Focusing Scale.—This is best done by photographing an object at a known distance and including also a series of objects at other known distances. It is convenient to use a series of cards, each bearing a number, and placed step-fashion one behind the other so that each is at a different distance from the lens. The scale is set to the precise measured distance of the middle card and a photograph is taken at the full aperture of the lens. If the middle card is the sharpest on the developed negative, the scale is correct; if not, the distance of the card shown sharpest indicates the distance upon which the lens was actually focused. A series of such tests at different distances can be used, if desired, to mark out a new and correct scale. (See also FOCUSING, and other references under that head.)

Focusing Screen. A ground-glass upon which the image formed by the lens can be seen. The best glass to use for this

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purpose is obscured patent plate, obtained by grinding patent plate with very fine emery.

Aids to Focusing.—Oiling the screen renders the grain of the glass much less obtrusive. Or a better expedient still for use with a focusing magnifier is a microscope cover glass cemented to the ground surface of the screen with a drop of Canada balsam; a small cross should be marked in pencil on the ground surface before doing this, or else, through the ready accommodation of the eye, this plan will prove a hindrance rather than a help. Both the cross and image should be in focus together. The easiest way of determining when this has been achieved is to move the eye from side to side, or up and down; if focusing is accurate, image and cross will remain in the same relative positions. If the cross appears to move over the image in the same direction as the eye, the camera-extension is too short; if the movement is in the opposite direction, it is too great. This method of focusing is only practicable if the camera is rigidly held on some support.

Fog is the term applied to a deposit of silver not forming part of the true image. It can appear as an even deposit over the whole of a negative or print, or as a streak or patch. It is in practically every case due to exposing the negative or paper to an unsafe dark-room light, to leakage in the camera, or to some other incidental and unintentional source of light.

The commonest cause of fog in modern practice is a camera that through some accident or defect is no longer light-tight. If the light enters the camera at a point remote from the film, fog is generally evenly distributed over the entire picture-area. Where the leak is near the film, fog may be expected to appear as a streak or patch covering only part of the negative. In this case it is usually easy to trace the leak by returning the film to the camera. The edge of the patch, usually its most intense part, will indicate the point at which light entered. Note that the edge of the film (outside the picture-area) will only be affected if the light-leak is *behind* the frame that delimits the pictures.

Often it is difficult to be sure whether a patch of fog that appears on a negative was due to light received while the frame was in place for exposure, or whether it was produced by light reaching the film before or after exposure, in one of the film chambers. To test, load a film into the camera, wind on to No. 2, and expose the camera freely to bright light for some time, making sure that all sides in turn receive direct

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sunlight. Without winding on the film, make a single exposure, and wind the film off for development. After development return the uncut film to the camera in the position it occupied during the test, as shown by the single exposure made. Any patch of fog will then be opposite the light leak to which it is due. Once the leakage of light is located, it is usually quite easy to find a means of stopping it up.

A film evenly fogged, edges and all, indicates in almost every case that it has been exposed to white light, or an unsafe light, in the dark-room (see DARK-ROOM ; SAFELIGHT). If so exposed only when partly developed, the image already developed up may actually be printed on the film itself, and on further development the resulting positive may swamp the original negative, so that the finished film shows a positive image.

On prints, fog can also arise through using an unsafe light, and may appear (usually as a yellow or grey mottling most apparent towards the edges), if the paper is very stale or has been badly stored. (See also BROMIDE PAPER.)

Apart from these errors or accidents in manipulation, fog can occur from some other causes. If an under-exposed plate or film is developed for a prolonged period in the endeavour to coax out an image, *chemical fog*, due to the reduction by the developer of unexposed silver bromide, may occur. Although this could be prevented by adding potassium bromide to the developer, this addition tends to slow the plate, and so to defeat the purpose of the prolonged development ; in such a case it is best to develop only till the first signs of fog appear, and then fix the negative.

Chemical fog is accentuated through using a wrongly-devised formula, containing too much sulphite or alkali, preparing it from impure materials—especially impure pyrogallol—or through development at too high a temperature. Choice of developing agent also has an appreciable effect, amidol and metol being much less inclined to give rise to it than either hydroquinone or pyrogallol.

Aerial Fog.—This variety of fog arises when the developer is unduly exposed to air, and may become troublesome in the see-saw development of films, or in developing films on a drum, for in either case the film, wet with developer, is freely exposed to air. Hydroquinone is more liable to give aerial fog than other developing agents, and developers containing it are best avoided when using the methods of development

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just mentioned. Two parts of either of the desensitizing dyes pinacryptol green or phenosafranine per million parts of developing solution will effectively check aerial fog, but in practice it is simpler to choose a developing agent, such as paraminophenol, which does not give rise to fog of this character.

Dichroic Fog.—This is recognisable by the fact that it is coloured, and has not the same colour by reflected light that it has by transmitted light. The colour is a manifestation of fineness of grain, and the fog is formed by deposition of silver from a developing solution containing much sulphite or other solvent of silver halides. Dichroic fog can often be wiped off the wet film ; after drying, it can usually be removed by a brief rinse in a permanganate bath followed by bisulphite treatment and thorough washing.

Often a film affected by dichroic fog gives the impression that it has not been fully fixed, and if, on trial with a fresh hypo bath, it is found that fixing can apparently not be completed, the presence of dichroic fog may be assumed. Some of the high-speed films will always show fog of this character when developed in a solvent developer. (See FINE-GRAIN DEVELOPMENT.)

Fog of all types, including a dichroic fog that does not yield to the treatment mentioned above, is best removed by treatment with Farmer's reducer (see REDUCTION, OF DENSITY).

Fog-Level. See *The Characteristic Curve*, under SENSITOMETRY.

Foot-Candela. Illumination on a surface placed at a distance of one foot from light-source of luminous intensity one candela. One foot-candela is equal to 10·8 lux, or 10·8 candela-metres. (See LUMEN, LUX, CANDELA, CANDLE-POWER. Also ELECTRIC LIGHT.)

Foot-lambert. A surface receiving an illumination of 1 foot-candle will have a brightness of 1 foot-lambert if it reflects the whole of the light incident upon it. (See also CANDELAS PER SQUARE FOOT.)

Formaldehyde, or Formic Aldehyde. See FORMALIN.

Formalin. The liquid sold under this name is a solution in water of formaldehyde, the gaseous aldehyde of formic acid ;

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this aldehyde having the composition of H.CHO, and the commercial solution usually contains 40 per cent. The solution of formaldehyde has such tendency to harden gelatine and make it insoluble that a film, whether on glass or on paper, can be made to resist the action of even boiling water by a soaking for 5 minutes in a mixture of 1 part of the commercial formalin with from 8 to 12 parts of water. It is seldom, however, that so strong a solution need be used, 1 part to 20 or 25 of water being sufficient for the prevention of frilling if 10 to 15 minutes is allowed. If negatives are are soaked for 10 minutes in the weaker formalin solution as given above, after the final washing, the film may be surface-dried with blotting paper, and then completely dried in a few minutes before a fire, keeping it in movement while drying. A lantern slide similarly treated may be exhibited at once in the lantern without fear of the film melting. One disadvantage of using formalin is that subsequent intensification or reduction sometimes becomes very difficult.

Formalin is chiefly used for hardening prints preparatory to glazing (*q.v.*); if hardening is omitted they are more liable to stick to the glass. Being a powerful antiseptic, it is also sometimes added to mounting pastes to prevent them from going sour in storage. See also SCRATCH-PROOF.

Formulæ, Chemical. See EQUIVALENCE, CHEMICAL; also WEIGHTS AND MEASURES and SOLUTIONS, MAKING UP.

Formulæ, Mathematical. See ALGEBRA.

F.P.A. See FILM PACK ADAPTER.

Free-Lance Photography. Photography done, on the initiative of the photographer, with the intention of offering the photographs for sale, usually to newspapers or magazines. Many an amateur, by spare-time work of this character, earns enough to pay for his hobby; a few make it a full-time occupation. See also PRESS PHOTOGRAPHY.

French Chalk. See CHALK, FRENCH.

Fresnel Lens. A lens of which one surface, instead of following a continuous spherical curve, takes the form of a series of stepped concentric rings, each with a curved surface. This enables the lens to be thinner and lighter, while still serving adequately for such equipment as spotlights, in which it is most commonly used.

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Fresson Process. See ARTIGUE'S PROCESS.

Frilling. By this is meant the gelatine leaving the plates or film in folds or wrinkles. It usually begins at the edges, and occurs chiefly when fixing, but often during development or washing. It occurs more frequently with plates than with films, and is generally started by the warmth of the fingers as they hold the plate by its edges. It can also be due to allowing too forcible a stream of water to impinge upon the edge of a plate, or the use of an exceedingly strong or very alkaline developer, or by differing temperatures and densities between the developing, fixing, and washing fluids. The use of a hardening fixer (*q.v.*) may be relied upon to prevent frilling.

Front-Cell Focusing. See FOCUSING.

F.R.P.S. Fellow of the Royal Photographic Society (*q.v.*).

Fuming. The process of subjecting sensitive albumenised paper to the vapour of ammonia. It was claimed for this that it rendered the prints more brilliant, that the paper printed more rapidly, and that it facilitated the toning. (See ALBUMENISED PAPER.)

Fuse.—Short length of readily fusible wire inserted in an electric circuit, its function being to melt, and so interrupt the current, if the current flowing should accidentally exceed some predetermined safe value.

Fuse-wire is rated according to the maximum current it should be used to carry; a 5-amp. fuse may be used in a circuit taking 5 amperes, but will melt if the current much exceeds this figure. Lamps and other electrical devices are rated, not by current, but by the power, in watts, that they consume, and the relationship between current and power depends on the voltage. The current taken by a lamp (or other device) is found by dividing the wattage by the voltage of the mains; a 1000-watt fire connected to 230-volt mains draws a current of $1000 \div 230 = 4{\cdot}35$ amperes. A 5-amp. fuse would thus be suitable, provided no other equipment is to be connected to the same circuit at the same time as the fire.

A 3-amp. fuse on a 220 volt circuit will permit $3 \times 220 =$ 660 watts to be used; to a circuit so fused it would be safe to connect two photoflood bulbs (275 watts each, total 550 watts) but if three such bulbs were used (total 825 watts) the fuse might be expected to blow.

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G

Gall. See Ox-Gall.

Gallate of Iron Process. See Ink Process.

Galvanography, Photo-. An old term for processes in which a printing plate or block is produced by electrotyping on a photographic original. (See Photo-mechanical Printing Processes.)

Gamma. A numerical measure of the extent to which a negative has been developed, indicating the proportion borne by the contrast of the negative to that of the subject on which it was exposed. (See Sensitometry for a more detailed definition. See also Gradient.)

Gamma Infinity, often written γ_∞, is the gamma reached by any particular plate when development is indefinitely prolonged. The value attained depends to some extent on the developer used. (See Sensitometry.)

Gaslight Paper. An old name for contact paper (*q.v.*).

Gauss Points. See Nodes, Nodal Points.

Gelatine. An animal substance obtained by boiling bones, hoofs, horns, and other animal substances. It contains about 15 to 20 per cent. of water at ordinary temperatures, and in cold water swells up and absorbs from five to ten times its weight. Good samples will absorb sufficient water to dissolve them when the temperature is raised above 90° F., the solution setting again to a jelly on cooling. The continued application of heat for some time destroys this setting power, a modification called metagelatine being formed. Gelatine will keep indefinitely in the dry state, but in the presence of water it

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soon putrefies, turning first acid and then alkaline; and at this stage ammoniacal vapours are given off. Alum, alcohol, carbolic, salicylic, and boric acids, thymol, formalin, and the salts of zinc act as antiseptics. Acetic, hydrochloric, sulphuric, and oxalic acids dissolve gelatine even in the cold —acetic acid very readily, and forming a useful liquid glue. Carbolic acid and alcohol precipitate it from aqueous solutions when they are in excess. Silver nitrate exposed to sunlight in contact with gelatine produces a red colour. The alkaline bichromates in solution of gelatine render the latter after exposure to light insoluble and incapable of absorbing water, this action being the basis of the carbon and nearly every photo-mechanical printing process. Formalin renders it insoluble. Chrome alum and tannin render it insoluble, but capable of absorbing water. Ordinary alum raises the melting point, but does not render it completely insoluble.

There is a chapter on gelatine in *The Theory of the Photographic Process*, by C. E. K. Mees.

Gelatine Emulsions. See EMULSION.

Gelatine-Sugar Printing Process. A printing process similar to gum-bichromate (*q.v.*) in which a mixture of gelatine and sugar replace the gum. In other respects the two processes are closely alike. Summarized instructions are as follows.

A tub-sized paper is to be preferred, but papers can be sized at home with chrome alum and gelatine as used for making single-transfer paper for the carbon process. The size should be rubbed well into the *back* of the paper. To coat, soak 3·5 gm. (150 gr.) of gelatine till soft, then add an equal weight of lump sugar and water to make 100 c.c. (10 oz.) Dissolve by gentle heat (110°–120°F.), then cool to 80° F., and hold at this temperature during coating.

A camel-hair mop is used to apply the solution, which should be used plentifully and worked into the paper till it froths. Then remove excess gelatine with a pad of clean butter-muslin, using a light polishing action. After drying for about half an hour, a second coat is applied. This usually suffices, but a third or even a fourth coat may be given.

When fully dry, the colour (ordinary artist's water-colour) is applied. Squeeze two or three inches of colour out of the tube, and slightly thin with water till quite liquid, but absolutely opaque when spread on white paper. Spread over the gelatine-coated paper with the camel-hair mop, and remove the

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surplus with a badger-hair brush, continuing to brush until the coating is even and surface-dry.

The paper will keep indefinitely in this state, but when sensitized must be used within twenty-four hours. To sensitize, immerse for one minute in 1 per cent. solution of ammonium bichromate, and dry in the dark.

The paper is about twice as fast as P.O.P., and requires a good strong negative—much more contrasty than is needed for gum printing. Expose to daylight, in the shade, under a negative ; an actinometer, and some preliminary experiments, will be needed to establish correct exposure.

Next immerse the print, face down, in warm water, taking care that the back of the paper does not rise above the surface, or dark marks will appear later. After ten minutes, place the print on a sheet of glass or wood supported on an easel, and develop by spraying with hot water. A hairdresser's spraying bottle provides a useful spray. When sufficiently developed, the print may be left to dry.

See also GUM-BICHROMATE PROCESS.

Gelatino-Chloride Paper. A paper for contact printing by daylight, during which process a visible or " printed-out " image is formed. Usually known as P.O.P., an abbreviation for " printing-out paper." First made by J. B. Obernetter of Munich, and put on the market in England by the Britannia Works Company (now Ilford, Ltd.) in 1891, P.O.P. rapidly superseded the albumen process that had previously been almost universal, but it has now in its turn been largely sup planted by development papers. It is still available, however, and though but little used in England finds a certain popularity among professional photographers in countries where there is a greater abundance of daylight. In the form of self-toning paper (*q.v.*), it was until recently still used by amateurs in this country, but is now no longer made.

Printing.—P.O.P. requires negatives that, by modern standards, are fairly contrasty, but some makes of paper are harder than others. With some papers more contrasty results are said to be obtainable by printing under green glass. In any case, the stronger the light used for printing the flatter will be the contrasts in the print.

Select a window-sill or other open space which has an uninterrupted view of the sky ; place the printing-frame there and leave it for a short time. Then withdraw it into a subdued light, and unfastening one of the springs, turn back

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half the back and examine the paper. The examination should not be too prolonged or the paper may be fogged.

The exact depth to which printing must be carried depends to some extent upon the toning-bath to be used, but as a rule it should be continued till the whites of the picture are well coloured and the shadows begin to block up.

The print is then finished as described under TONING (*q.v.*), and fixed in a plain (non-acid) fixing bath.

Genochrome.—Colour developing agent for colour reversal and negative films, and for colour printing paper, patented by May & Baker Ltd. SO_2 compound of di-ethyl-paraphenylene diamine, $(C_2H_5)_2\,N.C_6H_4.NH_2.SO_2.\frac{1}{2}H_2O$, M.W. $=237$. As compared with diethyl-paraphenylene diamine hydrochloride, it has the considerable advantage of oxidizing less readily, so keeping better as solid or in solution and being less prone to give colour fog. (See COLOUR DEVELOPING AGENTS.)

Ghost. See LENS; also FLARE.

Glass. Early specimens are a small tablet in the British Museum, about 1445 B.C., of Egyptian make, and a goblet found in Nineveh, of about 700 B.C. Glass as old as 5500 B.C. has been found in Egypt and it came from Syria, which, for many thousands of years, until A.D. 1400, was the centre of the glassmaking industry. Blown bottles and vessels were in common use in the 3rd century B.C., and the Syrians then developed window, or crown, glass.

Robert Lucas Chance introduced the manufacture of sheet glass into England in 1832, while British flint glass had become world-famous for its brilliancy as table-ware. The industry had been introduced into England during Queen Elizabeth's reign, when the French glassmakers, known for their religious independence, emigrated under persecution. Very thin plate glass can now be manufactured, with the result that photographic filters, usually consisting of tinted gelatine sandwiched between two optically flat discs of plate glass, can be manufactured accurately on a large scale. Owing to the difficulties of exactly matching coloured glasses, it is better to have gelatine sandwich filters for cheaper filters.

Coloured glasses are made by adding metallic oxides: blue from cobalt and copper oxides, red from manganese, copper, gold and selenium, green from chromium, nickel and copper, and yellow by the addition of carbon and cadmium. Some

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coloured glasses are "flashed," i.e., they are of colourless glass that has a thin layer of coloured glass welded to it. However, the colouring of glasses is beginning to become a science.

Glass usually consists of a mixture of silicates, and the raw materials are chosen from sand, red lead, potash, soda ash, magnesium, calcium and sodium phosphates and borates. The density varies from 2·2 for borosilicate glass to 5·2 for very dense lead glass. The denser the glass, as a rule, the greater the refractive index.

When Lucas Chance set up a small furnace at Smethwick and enticed Georges Bontemps, in 1848, to join him, the British optical glass industry was firmly established. Bontemps introduced "hard crown" and "dense flint," for telescopes, and "soft crown" and "light flint" glasses for camera lenses. He specialised in developing further denser glasses, which enabled the London lens manufacturers to replace Swiss lens blanks by British, and to supply most of the lenses for microscopes manufactured in Berlin and for the requirements of various Continental opticians.

Then, in 1866, Carl Zeiss was joined, at his Jena workshop, by Prof. Abbé, and in 1881 by Dr. Otto Schott. Schott made over 1000 experimental types of glass to enable Abbé to get rid of secondary spectra in achromatic lenses. The Prussian Government granted a subsidy, and the partly state-controlled industry that developed soon established something approaching a world-wide monopoly in many optical requirements.

When, in 1914, German supplies were cut off, the War Office, to their surprise and relief, discovered that Chance Bros. had installed the then latest grinding and polishing machines, electric annealing plant, and mechanical stirring machines. The output of British barium and zinc crown glasses, in new, gas-fired furnaces, reached several tons per month. Aerial photography, from 1916 onwards, created a wider demand, and glasses were manufactured to suit the lens-combinations required. The partial replacement of silica by boron oxide increased the refractive index without allowing the dispersion to go above 59, and the outstanding success was a glass of refractive index 1·614 and dispersion 59·9, making modern cinematograph lenses possible.

To-day bulk productions of normal types of optical glass are made by first slowly heating the pots to 1400° C., then adding the frit, or materials, topping to avoid shrinkage. After 30 hours, when the bulk is fairly free of bubbles, the temperature is lowered to 1000°C. and the stirring machine

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connected. The pots are then allowed to cool very slowly for seven days. The pot, containing up to 3000 lb of glass, is broken away, and the mass of glass broken into lumps and inspected for flaws.

The lumps are graded and passed into a kiln, where they are softened. Discs are pressed out of them, which, after treatment in a gas-fired furnace, are cooled very slowly in an annealing lehr, in order to eliminate internal strains and stresses. The blanks are then dispatched to the lens-makers, who cut and grind according to their own designs.

The electric heating of batches in platinum pots, which avoids the danger of impurities from clay pots, is being developed on a larger scale now that small batches have shown a high degree of homogeneity. The British industry, which has in Scotland its own supplies of special sand, is developing new glasses for transmission of specific portions of the visible and invisible portions of the spectrum, as well as for every optical purpose.

Glass, Burnt-in Photographs on. All the methods indicated under the heading ENAMEL AND CERAMIC PHOTOGRAPHS are available with glass as a basis. The glass is laid on an even bed of powdered plaster of Paris, then fired in the muffle.

Glass, Etching on. In the physical laboratory it is often desirable to etch scales on glass, and a photograph, whether of a line subject or a half-tone, has a special value when etched on glass, as fading, in the ordinary sense of the term, is out of the question. True, the photograph is extremely faint; but the details are well defined, and by filling the hollows with pigment any amount of vigour may be realised. The following method is extremely useful, as the positive used may be a transparency of a line subject or a transparency from a half-tone negative produced in combination with a line screen as in block-making. The following sensitive ground or resist is evenly spread on the glass:—Albumen, 120 grams; ammonia, 4 c.c.; fluid Indian ink, 8 c.c.; ammonium bichromate, 2 grams; water, 12 c.c. When dry, exposure is under a transparency (line or screen), and development is in cold water, the development being continued, with rinsing, until the portions to be etched are bare. After the resist is quite dry, the subject is bordered with wax, and the following etching fluid is used: Sodium fluoride, 10 grams; alcohol, 60 c.c.; water, 180 c.c.; glacial acetic acid, 4 c.c. (See also HYALOGRAPHY.)

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Glass, Silvering. (See MIRROR, SILVERING.)

Glass, Soluble. Basic alkaline silicates dissolve in water, and are sold as soluble glass. Used in preparing substrata for collotype (*q.v.*), and in other cases where it is desirable that a gelatine film should adhere very firmly to a glass plate.

Glauber's Salt. Popular name for Sodium Sulphate (*q.v.*)..

Glazing Prints. Prints with a glossy surface may be given a high glaze by squeegeeing them while wet on to prepared glass or a chromium-plated glazing sheet. The latter only needs careful cleaning and polishing for use. If glass is used it should be fairly stout and free from any surface blemishes. Patent plate is very suitable. The surface should be cleaned in hot water, with the addition of a little washing soda, and after rinsing in clean water, may be polished with a duster and a mixture of 10 per cent. ammonia and methylated spirit in equal parts. When thoroughly clean and dry, one side should have dusted over it a little French chalk, which must be rubbed lightly over the glass and then dusted off. There are other preparations which may be employed, and anything of a slightly greasy nature prevents the print from adhering, a solution of spermaceti wax applied with extreme thinness being sometimes recommended. Polishing with a rag moistened with a trace of paraffin has also been suggested, and special " glazing solutions " are offered by several makers.

The hardening of the prints with formalin or alum, though not always absolutely necessary, is an excellent precautionary measure against sticking. If formalin is used, hardening may be done immediately before laying them down on the glasses. It is not by any means necessary to spend much time in washing out the formalin, for as the prints dry the formalin evaporates, formalin as purchased being a solution of formaldehyde (a gas) in water.

The best way to lay the print on to the glass is to place the glass *in the water* in which the prints are soaking, floating a print face downwards over the glass. If the fingers are under the glass the print may be held in position by the thumb while the two together are lifted out of the water. In this way, air-bells between print and glass are avoided. The glass, with print adhering, is placed upon a flat, smooth surface—such as a firm table. A pad of newspapers makes a good base.

A sheet of smooth white blotting paper is then laid over the wet print or prints, a sheet of plain stout paper over that, and

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a flat squeegee is firmly and steadily passed over the print and glass, pressing out the moisture from centre to margins. Before standing up to dry examine the print *through* the glass and note if surface is perfectly clear and free from small air-bells. If not the squeegee should be applied again.

The drying of the prints after they are laid down on the sheets of glass must not be unduly hurried. If the prints have been hardened it is safe to use a slight degree of heat; that is, the glasses may be set in front of a fire at a distance of 5 to 6 ft., but beyond this it is not wise to go. One effect of too rapid drying is that the print dries round the edges, which then peel off the glasses, the centre, being still damp, adhering. Then, as the print dries inwards, it peels off a bit at a time, and when the print comes entirely away it shows a kind of oystershell mark. To avoid, this and all other troubles that may be met with in glazing, the following method of preparing the glazing surface has been recommended (Callier, 1924) and is claimed to be infallible.

Coat a piece of thoroughly cleaned glass with a warm 2 per cent. solution of gelatine, drain, and dry in a vertical position, protecting it carefully from dust. When completely dry, coat the gelatine with :—

Amyl acetate, to make . .	20 oz.	(1000 c.c.)
Pyroxylin	395 gr.	(45 gm.)
Oil of Vaseline . . .	17½ min.	(2 c.c.)

Drain off any excess, retaining it for future use, and leave to dry. The glass should be flat during drying, and to avoid falling dust should be covered by another sheet of glass. As amyl acetate is not very volatile, drying will take some time.

Prints are squeegeed wet on to the collodion surface in the usual way, and generally fall off of themselves when dry. The prepared glass may be re-used indefinitely as long as the collodion retains its polish. No further treatment of any kind is required during the life of the coating. (See also ENAMELLING, ENCAUSTIC PASTE, and MAGILP.)

Glycerine (Fr., *Glycerine ;* Ital., *Glicerina ;* Lat., *Glycerinum ;* Ger., *Glycerin*). $C_3H_5(OH)_3$. A peculiar, sweet, viscid liquid, obtained from oils and fats as a bye-product in saponification. Specific gravity, 1·260. It is extremely hygroscopic, and its non-drying properties are taken advantage of in photography to prevent the too rapid drying of some

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substances. It is miscible in all proportions with water and alcohol.

Glycin. Para-hydroxyphenyl-aminoacetic acid $(OH)C_6H_4NHCH_2COOH$ = 167. Synonym : Kodurol. Developing agent of low activity. Colourless crystals, practically insoluble in cold water, alcohol, and ether, but quite readily soluble in solutions of alkalis or alkaline carbonates. Hardly oxidised at all by air, whence its one-time popularity for stand development (see DEVELOPMENT.) At present occasionally used in fine-grain development (*q.v.*), and in developers for warm tones on chlorobromide papers. (See DEVELOPMENT and CHLOROBROMIDE PAPERS.)

Warning.—In buying glycin from a pharmacist, make sure he is not supplying glycine (aminoacetic acid) which is used in pharmacy, though not in photography. It has no developing properties at all.

Gold Chloride (Fr., *Chlorure d'or ;* Ital., *Cloruro d'oro ;* Ger., *Goldchlorid, Chlorgold*). Synonyms : Auric Chloride, Trichloride or Perchloride of Gold. $AuCl_3$ = 303. A yellowish-brown crystalline mass, made by dissolving gold in *aqua regia.* Usually commercial chloride is obtained by solution as above and the evaporation of the acid liquid, in which case bright yellow crystals of $AuCl_3HCl$ are obtained, from which it will be seen that one equivalent of hydrochloric acid is combined with it. Used in the toning of print-out papers of various types, for which purpose the double neutral salts of gold and potassium, sodium or calcium, are preferable. (See TONING.)

Gold Potassium Chloride (Fr., *Chlorure double d'or et de potasse ;* Ital., *Cloruro doppio d'oro e di potassio ;* Ger., *Chlorgoldkalium*). Synonym : Potassio-chloride of gold. $AuCl_3KCl\ 3H_2O$. The usual method of making this is to dissolve 1 part of pure gold in as small a quantity of *aqua regia* as possible, by the aid of heat. Evaporate gently, and then add 20 parts of distilled water, in which 0·51 part of potassium bicarbonate has been dissolved. Carbon dioxide is given off, and the resulting solution should be evaporated to dryness.

Gold Sodium Chloride (Fr., *Chlorure double d'or et de soude ;* Ital., *Cloruro doppio d'oro e di sodio ;* Ger., *Chlorgoldnatrium*). Synonym : Sodio-chloride of gold. $AuCl_3NaCl$

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Gold Thiosulphate

$+2H_2O$. This is the usual commercial salt, and occurs as yellowish-brown needles, which are very deliquescent, soluble in alcohol and water. The following table shows the equivalent quantities of the various salts used in photography :—

Gold.	Gold Chloride.	Gold Potassium Chloride.	Gold Sodium Chloride.
1	1·5420	2·1048	2·0229
0·6485	1	1·3645	1·3119
0·4751	0·7326	1	0·9611
0·4943	0·7623	1·0405	1

Gold Thiosulphate (Fr., *Hyposulfite double d'or et de sodium ;* Ital., *Ipolsolfito d'oro e di sodio ;* Ger., *Natriumaurothiosulfat, Unterschwefligsaures Goldoxydulnatron*). Synonyms : Hyposulphite of Gold, Sel d'or, Fordos and Gelis' salt. $Na_2S_2O_3$, $Au_2S_2O_3$, $4H_2O$. This salt was originally suggested for toning daguerreotypes, and later for albumenised paper, and more recently still for gelatino-chloride paper. It may be formed by gradually adding a neutral 2 per cent. solution of gold chloride to a 6 per cent. solution of hypo. To obtain it in crystals, mix the solution formed above with alcohol, when the salt will crystallise out in fine white needles.

Grade of Contrast. See CONTRAST GRADES.

Gradient. In sensitometry (*q.v.*) applied to the inclination or slope of the characteristic curve. Over the straight-line portion, that gradient is equal to gamma, and at any point on the curve, the gradient indicates the contrast at that point.

Gradient Speeds. Film speeds determined by finding the exposure needed to arrive at a point on the toe of the characteristic curve where the gradient is some definite fraction of either (*a*) gamma or (*b*) the average gradient over a predetermined range. A standard long accepted is that the gradient at the point in question shall be three-tenths of the average gradient over a log exposure interval, beginning at the point, of 1·5. (See SENSITOMETRY.)

Graduate. Alternative term for measure (*q.v.*)

Graduated Screen. See FILTER.

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Grain. The basic unit of weight in all three British systems of weights (Avoirdupois, Apothecaries, and Troy) and also in the American system. An idea of its magnitude may be had from the fact that a drop of water usually weighs between one and two grains. (See WEIGHTS AND MEASURES.)

Grain in Negatives. A negative is said to be "grainy" when an enlargement from it shows the structure of the image. Grain is usually most evident in the lighter half-tones, which may exhibit a mottled structure in place of a smooth even tone. (See FINE-GRAIN DEVELOPMENT.)

Gram *or* Gramme. The former spelling is virtually international, the latter specifically French. In English, "gram" is now more usual than "gramme." The gram is the unit of weight in the metric system. See WEIGHTS AND MEASURES.

Grey Scale. Scale of successive tones, from white to black, on paper or a transparent support. (See WEDGE and SENSITOMETRY.)

Ground-Glass. See FOCUSING SCREEN.

Guide Number. Also known as "flash-factor." See FLASHBULBS, EXPOSURES WITH.

Gum Arabic (Fr., *Gomme arabique ;* Ital., *Gomma arabica ;* Ger., *Gummi arabicum, Arabische Gummi*). A gummy exudation from the stems of various species of acacia. It is of peculiar bland taste, odourless, insoluble in alcohol and ether, but entirely soluble in water, in which form it is used as a mountant (*q.v.*). It is also used in the powder process, gum-bichromate, and photo-lithography. Its adhesiveness is increased by addition of aluminium sulphate, less so by ordinary alum. It is decomposed at a temperature of 300° F., and is converted into dextrine by the action of sulphuric acid.

Gum-Bichromate Process. In its original form, gum-bichromate appears to be chiefly due to M. Poitevin, Mr. John Pouncy, Mr. Thomas Sutton, and Mr. J. C. Burnett, who worked between 1850 and 1860, and it had a very considerable vogue in the early years of this century as a result of its revival by M. Demachy and others. The method may be summarised as follows :—Ground pigments are mixed with a thin mucilage of gum arabic and a little soluble bichromate,

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this mixture being applied to the paper as a thin wash. When dry, the paper is exposed to daylight under a negative, and the picture is developed by soaking in water (cold, warm, or hot) until the unexposed portions of the pigmented gum are sufficiently washed away.

The characteristics of the finished print, as well as the trouble involved in making it, are such that the process is hardly likely to be used except for fairly large work; it will therefore be necessary first to prepare an enlarged negative (*q.v.*). For ease in handling, this should be on a glass plate rather than on a film.

Paper for Gum-Bichromate Printing.—Generally speaking, any paper that would be suitable for water-colour painting will give satisfactory results in gum printing, and the choice of surface is of course one for the exercise of individual taste. English cartridge paper works well, but as it is rather heavily sized prints on it tend to hardness, though good and clear highlights are obtainable. Whatman's papers give excellent results, and the rougher kinds are well adapted for very broad effects.

Coating the Paper.—The following solutions should be made up :—

A.

Clear white gum arabic	4 parts
Water	6 parts

Soak till dissolved, and squeeze the mucilage through fine muslin.

B.

Potassium bichromate	1 part
Water	9 parts

In a room lighted by artificial light, equal volumes of A and B are mixed, and then such moist water colours are stirred in as will give the required tint; but the coloration should only be such that, when the preparation is laid on paper with a broad camel's-hair brush, as described below, the tint appears very faint, and far short of that required to form the shadows of a print. The film should seem very thin and transparent when the paper is held up to a window, and the outline of a finger held the other side of the paper should be easily traceable. Indian ink or ground lampblack, with a little cobalt blue to modify the greenish tint, is a suitable pigment. Earth colours, like Indian red or the siennas, can be used, but a much larger quantity is required than when lampblack is the

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base. To coat the paper it must be sponged on both sides to stretch it; after which it is pinned down on a board by one corner, and rapidly brushed over with the sensitive mixture by means of a broad camel's-hair brush. It is best to work in one direction, and the coating must be thin—so thin that the gummy mixture must rather be rubbed over the surface of the paper than painted on, and the pigmenting must be adjusted for this kind of coating. Some practice is required in coating the paper thinly and uniformly. A brush known as a " Badger-hair Softener " is useful here to lightly " whisk " over the surface of the coated paper to soften any inequalities.

The best method of drying is to hang the paper up overnight in a room where there has been a fire during the day, but more rapid drying before a fire is quite allowable. Exposure should generally be longer than for a print on P.O.P., and can be judged by the faint image of the exposed bichromated gum which is visible—or should be, if the paper is not too heavily pigmented—when the paper is viewed by transmitted light; the details in the shadows being just traceable. The use of an actinometer is often more convenient, especially for those who are accustomed to one. The exposed print is now soaked in cold water, and if the colour soon begins to wash off the paper on rocking the dish, under-exposure is indicated; and in this case cold water alone may perhaps finish the development.

According to the behaviour of the print, warmer and warmer water may be used, and to increase the detergent power of the water a stream may be poured from a height on the surface of the print. When the development is complete, the print may be soaked in an alum bath, after which it is rinsed and allowed to dry.

The Gum Solution.—The best gum arabic should be used, this occurring as nearly round and almost white nodules; these nodules being full of cracks. Such nodules as are clear and glasslike should be rejected, as these pieces are often but imperfectly soluble, giving rather a slimy mass than a true solution. Two parts of gum and 5 parts of water form a good standard mucilage. The mucilage should be strained, and to each half-pint or 250 c.c. add 20 drops of the pure crystallisable carbolic acid.

Choice of Pigments.—This is very wide, the one limitation being the exclusion of those which are affected by chromate salts. The following list includes all that are likely to be

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required :—Lampblack, ivory black, burnt umber, Venetian red, Paris blue, dark burnt ochre, sepia, gamboge, Pereira's green, and Cassel brown.

Stock Gum and Colour "Solutions."—These may be prepared by rubbing together in a mortar about 1 part of the moist water colour, as sold in collapsible tubes, with 4 parts of the mucilage or gum solution, but as some colours are more intense than others, no absolute rule can be laid down.

Mixing and Sensitising the Colour "Solutions."—In using the standard "solutions" of gum and colour to the required tint, the old dictum of the apothecary "shake the bottle" must not be forgotten. A mixture of 1 part of mixed or adjusted colour solution and 1 or 1½ of saturated solution of ammonium bichromate tends to hardness of the print and a rendering of the deep shadows; while the use of a mixture containing 1 part of the colour solution and 2 parts of a saturated solution of ammonium bichromate tends to greater sensitiveness, flatness of the picture, and the rendering of the fainter gradations. A sheet of paper 12 in. by 15 in. will ordinarily require a little more than ¼ oz. (about 8 c.c.) of the mixture, but this estimate is subject to much variation, as explained below. See above for instructions as to coating the paper. Dry as recommended above.

Exposures for Multiple Printing.—When several impressions are to be made on the same sheet to build up a picture, the question of exposure becomes somewhat complex. Let it be assumed that there are to be three printings. The first may be for the higher lights, and a range including all the darker shades. The paper being allowed to dry, and having been once more coated, the second exposure is for middle tones and shades, while the third coating and exposure may be merely to add to or intensify the shadows. Either the exposures may be about equal and the sensitive layers made of variable thickness, or the layers of sensitive material may be of equal thickness and the exposures may be varied; again, the proportion of bichromate may be varied as indicated above.

In the former case the first coating should be a thin layer of a mixture containing but little pigment and gum, but a full dose of bichromate. This will give a thin flat image. The second coating should have more gum and pigment with less bichromate, which, with the same exposure as in the previous case, will in no way increase the deposit on the higher lights. The mixture for the third coating will be made with

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still more gum and pigment, but with less bichromate. If the exposure is the same as before, only the deeper shadows will receive a new deposit. If, on the other hand, the system of varying the exposures and using similar coatings be adopted, the first exposure must be long so as to cause a deposit as far as the lights of the print, this exposure giving a flattish picture. The second exposure must be shorter, the deposit then only reaching the middle tones, while the third exposure should be so short as only to cause a deposit on the extreme shades.

Adjusting the Print to the Negative for Multiple Printing.— The coating of pigmented sensitive gum on the sheet of paper should never be so thick or dense as to make it difficult to place the negative in exact position or register for the subsequent printings. An excellent method of adjusting the sheet for subsequent impressions is to hold the negative and sheet together in one hand, until exact correspondence is effected, and then to fix the paper in position by strips of adhesive plaster, this latter being very slightly warmed.

When dealing with large prints an excellent method of securing register for several coatings is the use of a drawing-board instead of a printing frame. This has the further advantage of allowing the whole of the print to be examined during exposure. A piece of stout flannel must be attached to the board, and upon this is laid the gum-bichromate paper, sensitive side uppermost. When cutting up the paper, a margin of about an inch larger than the negative must be provided.

Pin the paper to the board by the four corners, and in the centre place the negative. Some ordinary pins of a fairly stout gauge are now required, and two of these must be driven through the paper into the board, so that they press firmly against the glass on all sides.

A few drawing pins can be used to ensure contact if desired. This is only necessary if the negative is not a very large one. If a large glass negative is used, its weight is generally sufficient to keep it in good contact with the paper. Printing should be conducted with the board as nearly horizontal as possible. A good top light or printing in the open air is advisable. When it is necessary to examine the print, the negative is removed altogether, and if the pins have been accurately fixed, it can be replaced in exact register.

Gum-Bichromate-Alum Process. This process, which is due to Mr. Herbert S. Starnes, and was shown by him at the

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Royal Photographic Society's Exhibition, 1919, is another variation of the gum-bichromate method previously described :

Specially ground pigments and gum senegal are added to the sensitiser (a solution of sodium bichromate, alum, and hydrochloric acid). The mixture is brushed thinly over raw paper (not more than 1 minim to 4 sq. in., or 1 c.c. to 450 sq. cm.). The paper is then dried and exposed under the negative. A weak solution of alum and hydrochloric acid is poured over the print. In about 10 sec. the soluble pigment will begin to float off the highlights, and when the lightest half-tones are visible, the acid alum will have acted upon the entire film according to the light action. The soluble pigment can then be washed away, *or left*, as desired, by developings with water under pressure.

Gum-Printing on Bromides. A method of making a print in pigment, without using a negative, on a bromide print or enlargement. This process, due to T. H. Greenall, bears the same relationship to gum-bichromate that Carbro does to carbon. Usually the original silver image is left to re-inforce the pigment.

The bromide print, on non-supercoated paper, should show full highlight detail without being veiled or over-exposed. It should be fixed in a hardening fixer (or otherwise hardened) and well washed.

For the coating, mix 1 part sugar and 2 parts white dextrine with 12 parts water and heat till clear. To 8 parts of this add 4 parts of 8 per cent. gelatine solution and 6 parts of 15 per cent. gum arabic mucilage. For a black print, 1 part of vegetable black and 2 parts of ivory black, mixed, are rubbed into 125 parts of the above colloid mixture, the mixing being done with a spatula or thin flexible knife on a sheet of glass. Or 1 part of vegetable black alone may be mixed with 80 to 110 parts of colloid solution. For a print that is to be sulphided, 1 part ivory black to 22 parts colloid, or 4 to 5 parts bone brown and 1 part ivory black to 110 parts colloid, will be found pleasing.

Damp the surface of the print just enough to make it lie flat, warm the coating mixture till it is about as thin as office gum, then spread on the surface with a very soft flat hog-hair brush, smoothing with a badger softener. Allow 30 to 45 minims (about 2 c.c.) for a 5 × 7-in. print.

When dry, treat print for 1½ to 2 min. in :—

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A.	Copper sulphate . . .	20 gr.	(2·5 gm.)
	Potass. citrate (neutral) .	80 gr.	(10 gm.)
	Water	20 oz.	(1000 c.c.)
B.	Potass. ferricyanide . .	40 gr.	(5 gm.)
	Potass. bromide . . .	20 gr.	(2·5 gm.)
	Water to	20 oz.	(1000 c.c.)

These solutions keep fairly well. For use, mix 1 part A, 1 part B, and 2 to 4 parts water. The stronger the solution the heavier and more general is the deposit of pigment. If too much pigment is persistently deposited, double the amount of potassium citrate. The surface of the print must not be touched.

The print is next treated with successive changes of tepid water, each warmer than the last, starting at 80° F. This washes away the pigment in the lighter parts, leaving it attached in the shadows, so producing the pigment image. For local development, allow cold water to drop on to the print as it lies under the warm water.

Lastly, redevelop the partially-bleached silver image in any ordinary developer, preferably free from bromide, wash carefully and dry. Redeveloping may be omitted if the print is to be sulphide toned. In this case, first treat for 1 to 2 min. with 0·2 per cent. caustic soda, rinse, and immerse in 2 per cent. hydrochloric acid; then wash in numerous changes. This gets rid of any copper that the print may have retained. Then bleach and sulphide in the ordinary way. (See TONING.)

Gun-Camera. A camera attached to a gun, usually in a fighter aeroplane, and operated when the trigger of the gun is pulled. These cameras were introduced during the First World War for use in training fighter-pilots. The photographs taken in a practice "dog-fight" enabled the instructors to determine whether the opposing aircraft would have been shot down if the gun had been actually fired.

In this early model only still pictures were taken; modern gun cameras use 16-mm. film and make a complete record of the whereabouts of the opposing aircraft throughout the whole period during which the trigger of the machine-gun or cannon is depressed. In real fighting it is usually possible to determine from the film whether the enemy aircraft was brought down, or to what extent it was damaged. From this point of view the cine gun-camera is so valuable in wartime that it is now fitted as standard to most fighter aircraft as well as to training machines. See also AERIAL PHOTOGRAPHY.

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H. & D. An abbreviation for Hurter & Driffield, the two pioneer investigators in sensitometry. The letters H. & D. seen on a box of plates together with a number—thus, H. & D. 1000—indicates that the speed of the plates has been determined to be 1000 according to the H. & D. system of measurement. The numbers are comparative: thus, H. & D. 200 is double the speed of H. & D. 100, or half the speed of H. & D. 400. (See also EXPOSURE and SENSITOMETRY.)

Halation. A spreading of light from a bright part of the image into an adjacent darker part as a result of reflection from the back surface of the film or plate (compare IRRADIATION). Halation makes itself most obvious when photographing on an unbacked glass plate an interior view that includes a window. Both direct and scattered light from the window pass through the sensitive coating of the plate, and is reflected from the back surface of the glass. It then strikes the back of the emulsion in the neighbourhood of the image of the window, so that on development this is surrounded by a heavy black halo (white on the print) decreasing in intensity at increasing distances from the window. The same effect can result in wiping out the image of twigs seen dark against a light sky, and in general tends to obscure the outline at any point where there is a sharp contrast between light and dark, especially when full exposure is given.

Halation is present in films as well as plates, though with the thinner support its effects are less evident. It can be checked either by interposing a light-absorbing layer between emulsion and the celluloid or glass, or by abolishing the optical surface at the back of the support. The latter is the principle used in " backing " plates ; they are coated with an opaque substance of the same refractive index as glass.

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There is thus no reflection at the glass-backing surface, and in the backing the light is absorbed. For backing to be effective, no air must be trapped between the glass and the backing; they must be strictly in optical contact. All plates are obtainable ready-backed, and practically all films are protected against halation either by backing or by an intermediate anti-halo layer immediately below the emulsion. In 35–mm. films, the base is often tinted grey as a preventive of halation.

Halation, when it occurs, can to some extent be cured by local reduction (of density), (*q.v.*), by the process of redevelopment (*q.v.*) or by the careful use of Baskett's reducer (*q.v.*). (See also BACKED PLATES.)

Half-Plate. The size $4\frac{3}{4} \times 6\frac{1}{2}$ in. Note that it is not the half of a whole-plate ($6\frac{1}{2} \times 8\frac{1}{2}$ in.) which would be $4\frac{1}{4} \times 6\frac{1}{2}$ ins. This size is now never used, but has sometimes been referred to as " double quarter." (See SIZES PHOTOGRAPHIC.)

Half-Silvered Mirror. Glass or other support coated with so thin a layer of silver that it reflects about half the light incident on it and transmits the other half. Used in rangefinders (*q.v.*).

Half-Tone Blocks. See PHOTO-MECHANICAL PRINTING PROCESSES.

Halide, Haloid. See HALOGENS.

Halogens. Generic term for the four closely-related elements fluorine, chlorine, bromine, and iodine. Salts of the corresponding hydro-acids (hydrochloric, etc.), are often known as halides, haloid salts, or sometimes as " haloids."

Hand Camera. The hand camera may be said to date from the introduction of the dry plate, which first freed the photographer from the necessity of taking a complete laboratory for the preparing and developing of his plates to the site of his proposed photography. The early hand cameras, frequently known as " detective cameras," were in most cases either a simple box or a stand camera more or less crudely adapted for use in the hand by the addition of a focusing-scale and a view-finder to replace the ground-glass screen. From one or other of these all subsequent hand cameras have evolved. (See CAMERA.)

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Hand Camera Work The tripod, not so very long ago essential for all but special work, is now so seldom used that "hand camera work" includes practically the whole of modern photography. We therefore deal here with a few points common to all work with a hand-held camera, but chiefly matters that become important when using a hand camera for the rapid snapshotting for which it was originally designed.

Camera Shake.—Slight movement of the camera during exposure is far more often responsible for slight loss of sharpness than is generally realized. The lighter the camera, the harder it is to hold it perfectly still, and with cameras weighing no more than a pound or so many workers cannot be sure of perfectly sharp negatives at exposures longer than 1/100th or even 1/200th second, unless they use some kind of support either for the camera or for themselves. With heavier cameras slower speeds, down to 1/50th or even 1/25th second, may often be used without serious risk of loss of definition. Much also depends on the individual user, and on the way he holds his camera, but any worker can find whether he, personally, may use some particular shutter-speed without risk of shake by making a dozen exposures at this speed on some subject rich in fine detail. Only if *all twelve* negatives are of full and *equal* sharpness is that speed safe for him to use.

With the usual eye-level finder on a small camera, it is probably best to hold the body of the instrument in such a way as to allow the knuckles of the thumbs to be pressed firmly against some part of the face, so that the camera cannot be moved without moving the head also.

The shutter release should always be depressed slowly, with a squeezing action like that used in firing a rifle. A sharp dig at the release is fatal; it is only permissible when a fast-moving subject has to be caught at precisely the right moment, in which case a very high shutter-speed must be used, as much to guard against camera shake as for the sake of arresting the movement of the subject.

On the slower speeds of 1/100th of a second or longer, it is a good plan to hold the breath when releasing the shutter, particularly when using a reflex or other camera that is used at waist-level. Some workers find it helpful to use a wire release, but others prefer the normal shutter release. The general adoption of body-release (*q.v.*) of late years has done much to eliminate camera-shake, but it should be noted that a stiff or jerky release can accentuate or cause it.

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Judging Distances.—One of the greatest difficulties in hand camera work is focusing. Although a tape measure or a range-finder can be used to determine the distance of the object, the undeniable fact remains that if the judgment is sufficiently cultivated to enable the photographer to estimate distances nearly enough by eye, he can work much more quickly than if he had to rely on measurement. Even a coupled range-finder, the quickest of all mechanical methods of determining distance, consumes moments that may be precious. Every photographer, no matter how well equipped his camera, should therefore be able to estimate distances by eye; for the user of the simple camera this is an essential accomplishment.

A good method of training the eye can be made use of at any time when out walking. Choose a number of feet, say fifteen, and as each street-corner, lamp-post, pillar-box, or other object is approached a guess is made as to the exact instant at which it is the prescribed 15 ft. away. Count steps from that instant until the object is reached, thus roughly measuring the distance. A yard is a good full stride; if a shorter stride is habitually used, the number of normal paces in 15 ft. can be determined in advance.

This process of measurement is repeated on every conspicuous object approached, and in a day or two the 15-ft. distance will be very easily recognised with considerable accuracy. Next take some other distance, say 9 ft., or whatever is marked on the focusing scale of the camera, and continue the exercise as before. Several distances can soon be learnt in this way, with no special trouble or consumption of time, simply by making use of opportunities when walking in town or country.

The next stage is to stop at all sorts of irregular distances from the object being approached; guess the distance, and check it, as before, just by walking up to it. Then the ability to judge distances can be made use of photographically and out-of-focus results should be very rare.

Another useful method of estimating distances is to note the apparent size of an average man as seen in the view finder at various distances. A standing figure should be viewed at various distances, and the size memorised. With practice, it becomes no more difficult to estimate the distance from the size of a seated figure than from that of a standing one.

Where it is not desired to rely upon an estimation of distance, or for close-up work where estimation is hardly likely

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to be accurate enough, a range-finder should be obtained for use in conjunction with any camera that is not fitted with one, unless, of course, it is a reflex. For convenience, a clip to hold it should be attached to the camera.

Inspection of a depth of focus table (see DEPTH OF FOCUS) will immediately show how the accuracy required in judging distances varies with the distance of the object, and with the stop used, and will indicate when it is safe to rely upon judgment, and when a range-finder must be used to ensure a sharp picture.

Subjects.—The ease with which the modern camera can be used is meant to enable the user to concentrate all his attention on the subject. Too often it has the effect of encouraging snapshotting of the most casual type, with no care or thought devoted to the choice and arrangement of subject. The picture-maker, if his aims are serious, must guard against the tendency to snapshot too promiscuously.

For other matters connected with hand cameras and hand camera work, see under respective heads :—LENS, EXPOSURE, FOCUSING, HYPERFOCAL DISTANCE, DEPTH OF FOCUS, MOVING OBJECTS, MINIATURE CAMERAS, SHUTTER, DEVELOPMENT, FINE-GRAIN DEVELOPMENT, WATERBATH DEVELOPMENT, FILMS, and CAMERA.

Hand and Stand Camera. See under CAMERA.

Hardening Agents. The gelatine which is the vehicle for the sensitive silver salts in plates and films will soften if immersed in water, or in ordinary developer or fixer. At too high a temperature this softening may lead to melting, frilling, or reticulation, the latter being particularly associated with sudden changes in temperature, as from developer at 65° or 70° F. to wash-water straight from the tap at perhaps (in winter) 45° F. or less. All these causes of failure can be avoided by hardening (tanning) the gelatine.

The usual hardening agents are potash alum, chrome alum and formalin, and of the three potash alum is the most widely used, largely because it can conveniently be incorporated in the fixing bath. (See HARDENING FIXER.) It is important to notice that the hardening efficiency depends very greatly on the acidity of the solution, reaching a sharp maximum at a *p*H of about 4·0. A hardener containing 1½ per cent. of potash alum, used at this *p*H value, may be expected to raise the melting point of the gelatine from its normal value of about 90°–95° F. to about 110°–115° F. With a 5 per cent. alum

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solution, the melting point may be raised as high as 155°–160° F. But if the acidity of the solution is wrongly adjusted, the hardening effect of the alum may be negligibly small.

Chrome alum behaves in much the same way as potash alum, but is a more efficient hardener, capable, in favourable circumstances, of raising the melting point of gelatine to over 200° F.; the optimum *p*H for the solution is 4·3; which is about that of a simple solution of chrome alum. Note that chrome alum solutions containing sulphite lose their hardening properties within about 24 hours of mixing; similar solutions of potash alum retain their hardening properties for long periods. Stock hardening fixers must therefore be made with potash alum and not with chrome alum. It is interesting to notice that carbon, gum-bichromate, bromoil, and similar processes depend on the chrome hardening of gelatine or related substances, the chromium salt being derived from a bichromate by the action of light or of the silver image.

Where hardening in neutral or alkaline solution is required, alums are totally ineffective, and formalin (*q.v.*) must be used. The chief practical applications of this are in tropical work (*q.v.*), and as post-fixation hardener, especially for prints that are to be glazed or for films to be protected against subsequent mechanical injury. (See SCRATCH PROOF.)

Temporary "hardening" can be provided by loading a developer or other processing solution with almost any neutral salt; the effect here is simply to prevent the gelatine from swelling as long as it is in the solution. A 10 per cent. addition of sodium sulphate is commonly made to developers for tropical work; this enables true hardening to be postponed until development is complete. (See TROPICAL WORK.)

Hardening Fixer. A fixing bath that also contains ingredients for hardening the gelatine. The usual hardening agents that are added to a fixing bath are ordinary white (potash) alum or chrome alum. In addition, the bath must be made acid, to prevent precipitation of the aluminium or chromium, and must contain some sulphite to protect the hypo from decomposition by the acid. (See ACID FIXING BATH.)

Of the two, chrome alum hardens more decisively than potash alum, but it is not in general suited to amateur use, as it loses its hardening properties within a few days of mixing, no matter whether it is made up as a complete fixer or as a separate hardener to be added to the hypo at the time of use. Baths containing ordinary alum will keep almost indefinitely. Moreover, recent work has shown that a potash alum bath has its life

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greatly extended by the addition of boric acid, in the presence of which it retains its hardening powers at least three times as long. The boric acid also makes the bath less likely to deposit a white sludge of aluminium sulphite or hydroxide during use.

The following hardening fixer (F5) has good hardening properties and a long life.

Water (about 125° F.) . .	12 oz.	(600 c.c.)
Hypo	4¾ oz.	(240 gm.)
Sod. sulphite (anhydr.) .	130 gr.	(15 gm.)
Acetic acid (glacial) . .	125 min.	(13 c.c.)
Boric acid (crystals) . .	65 gr.	(7·5 gm.)
Potash alum . . .	130 gr.	(15 gm.)
Cold water up to . .	20 oz.	(1000 c.c.)

For more accurate measurement, it is better to prepare a 28 per cent. solution of acetic acid by mixing 3 parts of glacial acid with 8 parts of water, and take 7¼ dr. (47 c.c.) of this in place of glacial acid.

It is essential that the chemicals should be dissolved in the order shown. Each 20 oz. of this will fix, as an absolute maximum, twelve 3¼ × 2¼ spools 24 V.P. spools, or twelve 36-exposure lengths of 35-mm. film. Films must be rinsed in water, or a hardening stop bath (*q.v.*), between development and fixation, or the life of the bath will be considerably less than that given.

If preferred, a concentrated acid hardener can be prepared by omitting the hypo and dissolving the remaining chemicals in one-fifth of the quantity of water shown. For use, mix one part of this solution with four parts of 30 per cent. hypo.

Hardening Stop Bath. A hardening bath that also contains an acid to arrest the progress of development. It is used after development and before fixation. An effective formula is :—

Chrome alum . . .	180 gr.	(10 gm.)
Sodium bisulphite . . .	180 gr.	(10 gm.)
Water to	20 oz.	(500 c.c.)

The sodium bisulphite may be replaced by its own weight of potassium metabisulphite if preferred. The developer is poured out of the tank and immediately replaced, without intermediate washing, by the above. After 5 to 10 minutes, the hardening stop bath is poured away and replaced by fixer. This should either be a hardening fixer or should

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contain metabisulphite in fair quantity, otherwise the chrome alum carried over may either decompose the hypo or produce a precipitate in the film.

The hardening stop bath must be freshly made; it can be used for several films in succession on one day, but loses its hardening properties if kept for more than about 24 hours. Or it may be mixed as required from 15 per cent. solutions of the separate ingredients, which keep well separately.

Alternatively a 3 per cent. solution of chrome alum (300 grains per 20 oz.) may be used; this will keep indefinitely in solution. It may be made up five times this strength if preferred, and diluted for use. Agitate the film in it for not less than 10 seconds, then leave 5 minutes to harden before fixing.

The solution loses its hardening properties through use; so long as it remains blue-violet in colour when looked through in artificial light it will still harden. When it shows signs of turning yellowish-green it should be discarded.

This change is not always easy to detect; a simple plan is to have two identical bottles of the working-strength solution. When the bottle in use ceases to be indistinguishable in colour from the unused bottle, its contents are discarded and the second bottle is taken into use. The first bottle is refilled with fresh solution, and becomes the colour standard.

Harmonising Harsh Negatives. This is an exceedingly valuable process, as it combines intensification of the shadows with reduction of the highlights. It is particularly helpful when dealing with a negative that has been slightly under-exposed and then over-developed.

The procedure is simply that of chromium intensification (see INTENSIFICATION), except that redevelopment is only partial. It is continued until the shadows and medium half-tones are redeveloped right through (and consequently intensified) but is interrupted by fixing the negative while the highlights are still incompletely re-blackened. As the hypo dissolves out the still undeveloped parts of the image, the denser portions of the negative are effectually reduced.

If reduction of the denser parts without intensification of the shadows is desired, a ferricyanide and bromide bleacher as used for sulphide toning (see TONING) should be used in place of the bleacher indicated above.

Warning. The loss of strength in the hypo is greater than the inexperienced worker generally expects. Those about to

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use the process for the first time should experiment first with a waste negative, or they may seriously misjudge the extent of re-development.

Heat Filter. A filter placed between lamp and condenser in a projector (or enlarger) to aid in keeping condenser and transparency (or negative) cool. A cell filled with water has been used in the past, but the modern type of heat-filter consists of a sheet of special heat-absorbing glass about a quarter of an inch thick. To prevent it from cracking, the glass is generally divided up into a series of parallel strips about half an inch wide, with their edges in contact. If placed close against the condenser, no image of the lines between strips will appear on the screen.

It may be added that no heat filter can be really effective unless adequate ventilation of the parts to be kept cool is provided. The light-chamber must always be so designed that there is a continuous current of air through it (maintained in motion by the heat of the lamp) and some part at least of the entering air should be constrained to pass over the condenser or transparency. (See PROJECTOR and ENLARGING).

Hecto-. Prefix used in the metric system (*q.v.*) to signify "one hundred." For example, a hectolitre is a hundred litres.

Heliography. An old name for photography.

High Definition Developer. Trade name of a Kodak developer designed to enhance the apparent sharpness of a negative image. This it does by producing, at any junction between two different tones, an increased density at the edge of the denser tone and a reduced density at the edge of the less dense tone. The increased contrast gives the impression of greater sharpness. The effect is produced by the local exhaustion of the developer, and in consequence can be increased or decreased by giving less or more agitation during development. If too little agitation is given, each dark object (in the print) is surrounded by a noticeable white line.

High Key. Term applied to a photograph in which all, or nearly all, the tones are light and delicate. High key pictures cannot be made simply by making a light and soft print; the original subject itself must be of high key character.

High Lights. The brightest parts of a picture, which are represented by the greatest density in the negative, as the

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face in portraits, the sky and other bright portions in the landscape.

History of Photography. See PHOTOGRAPHY.

Hood. See LENS-HOOD.

Horizontal Enlarger. See ENLARGING.

Hyalography, Photographic (ὕαλος, glass or crystal). Numerous processes for photographic etching on glass have been known by this name. The following is a simple method, giving good results. Paper is coated with the following :—

Water	10 parts
Sugar	1 part
Gum arabic	1 part
Ammonium bichromate . . .	1 part

Expose under a transparency and dust with fine bitumen, as in powder process (*q.v.*). Transfer to warm glass so as to soften bitumen, soak off paper, dry glass, and etch with vapour of hydrofluoric acid. (See GLASS, BURNT-IN PHOTOGRAPHS ON.)

Hydrate. A chemical compound containing water. Generally applied to crystals in which the water is present as "water of crystallisation." For example, crystalline sodium carbonate, $Na_2CO_3 10H_2O$, may be referred to as "the hydrate" when contrasting it with the anhydrous salt. It must not be assumed that all crystals are hydrates; many contain no water.

At one time "hydrate" was often used to mean "hydroxide" (*q.v.*), but this usage is now considered incorrect.

Hydrochinon. See HYDROQUINONE.

Hydrochloric Acid (Fr., *Acide chlorhydrique ;* Ital., *Acido chloridrico ;* Ger., *Chlorwasserstoffsäure ; Salzsäure*). Synonyms: Muriatic acid, spirits of salts. Solution in water of the gas hydrogen chloride HCl. A solution saturated at 15° C. contains 44·3 per cent. of pure HCl, but the strongest acid normally sold is a little weaker, containing about 36 to 38 per cent. of the gas (density = 1·19). It can be made by decomposing common salt with sulphuric acid. Reacts with alkalies and bases to form chlorides.

Its chief photographic use is in a bichromate bleacher for intensification or toning, and for cleaning dishes and other

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utensils. For the latter use the yellowish commercial acid is pure enough.

Store in a bottle with glass stopper. The concentrated acid will attack mouth, throat or eyes, but is harmless to whole skin if not left on it too long.

Hydrogen. H=1. A gaseous element of very frequent occurrence in nature in a combined state, especially in the form of water. It is taken as the unit of atomic weights. It is the lightest element known, and is a major constituent of coal gas. The prefix hydro- or hydr- of chemical names is often a secondary derivative from hydrogen.

Hydrogen Peroxide (Fr., *Eau oxygénée;* Ital., *Acqua ossigenata;* Ger., *Wasserstoffsuperoxyd*). $H_2O_2=34$. Synonyms: Dioxygen, Hydrogen dioxide. The usual "20-volume" solution, which on decomposition of the H_2O_2 would give 20 times its own volume of oxygen, is approximately a 6 per cent. solution of pure H_2O_2. It is a powerful oxidising and bleaching agent. Its chief photographic use is as a hypo-eliminator (*q.v.*).

Store in a cool place, in incompletely filled bottles not too tightly stoppered. Neutral or acid solutions of hydrogen peroxide, or their vapours, will fog undeveloped sensitive materials.

Hydrokinone. See HYDROQUINONE.

Hydrometer. The hydrometer is a spindle-like float, generally made of glass, and with a graduated stem which indicates the specific gravity of a liquid by the depth to which it sinks. Hydrometers, graduated for special use so as to give directly the strengths of alcohol, ether, acids, or saline solutions, can be obtained from dealers in chemical apparatus; but the most generally useful graduation is that which gives the specific gravity.

Hydroquinone (Fr., *Hydroquinone;* Ital., *Idrochinone;* Ger., *Hydrochinon*). $C_6H_4(OH)_2=110$. Synonyms: Hydrokinone, Hydrochinon, Quinol. Chemical name: Paradihydroxybenzene. White crystalline needles, darkening slowly on exposure to air. Solubility: 4·25 per cent. in water at 0° C., 10 per cent. in water at 30° C.; soluble also in alcohol, etnes, and glycerine. It is allied to pyrogallol in chemical

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composition, pyro being a trihydroxybenzene, $C_6H_3(OH)_3$. It is one of the most inexpensive developing agents, and is very widely used. By itself it is chiefly used in "high-contrast" developers for process plates, for which its low Watkins factor, high sensitivity to bromide, and clean working make it specially fitted. It is also largely used for producing warm tones on chlorobromide papers. With a small addition of metol it makes the enormously popular "M-Q" universal developer. which gives excellent results with plates, films, lantern-slides, and development papers of every type. Its main disadvantage is that it rapidly loses energy with falling temperature. Chlor-hydroquinone (see under CHLORQUINOL), and brom-hydroquinone may be used in place of hydroquinone, and are comparatively free from this defect. Hydroquinone is very prone to produce aerial fog (see FOG) and developers containing it should not be used for see-saw or drum development unless the film is first desensitised, which prevents this form of fog. (See DEVELOPMENT.)

Hydroxide. Substance containing a hydroxyl (OH) group that is capable of being replaced by an acid radical. If soluble, a metallic or pseudo-metallic hydroxide gives a strongly alkaline solution. Ammonia, caustic soda, and quicklime (calcium hydroxide) are typical of the soluble hydroxides.

Hyperfocal Distance. If a lens is accurately focused on an extremely distant object, then the nearest object whose image is sufficiently sharp on the film is situated at the hyperfocal distance. Besides depending on the focal length and aperture of the lens, the exact value of the hyperfocal distance evidently depends on what is considered "sufficiently sharp."

The degree of sharpness reached is generally described in terms of the "circle of confusion." If a mathematical point is photographed, the image, if exactly focused by a perfect lens, will also be a point. Some departure from mathematical perfection is, however, permissible before the image becomes noticeably blurred, and if the focusing is so far inexact that the point of light is represented by a small blurred disc of diameter $\frac{1}{100}$ in., the blur resulting is said to be that corresponding to a circle of confusion of $\frac{1}{100}$ in.

If the diameter of this circle is represented by C, then when the lens is focused for infinity the distance from the camera

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of an object so far out of focus that each point on it is represented by a circle of diameter C will be given by :—

$$H = \frac{f^2}{nC}$$

Where f = focal length of lens
$n = f$/number of stop in use.

The distance H found from the above formula is the hyperfocal distance. In using the formula, H, f, and C must all be expressed in the same units.

It should specially be noticed that the formula just given is the fundamental one. Nothing other than basic optical laws has been assumed in finding it, and it applies in every case. This is stressed because various formulæ for finding hyperfocal distance appear in photographic literature, and at first sight some of them seem inconsistent with that above. In fact, all such formulæ are derived from the one just given by replacing C (which is perfectly general) by someone's idea of what value the circle of confusion should have for the type of work he has in mind. Such formulæ are perfectly legitimate, and are often very valuable for the purpose for which they were designed, but unless the assumptions made in them are clearly realized, it is only too easy to apply them unwittingly to circumstances which they do not fit. If in doubt, go straight back to the formula above ; it may be more troublesome to apply, but it is always safe.

We proceed to derive some alternative formulæ for special cases ; the applications, and limitations, of each are clearly explained. In all such formulæ, the diameter of the circle of confusion is chosen to suit the type of work in mind.

It was usual, in the days when negatives were printed exclusively by contact, to take as a criterion of " sufficiently sharp " that a point should not spread to a disc greater in diameter than $\frac{1}{100}$ in., on the grounds that the amount of blur so produced was just barely perceptible to the eye at the normal viewing distance of some 10 in. Now that nearly all negatives are enlarged, it is perhaps more profitable to set the limit of sharpness on the enlargement rather than on the negative, so that the smaller the negative the higher is the standard of sharpness demanded on the negative itself.

To find the corresponding circle of confusion on the actual negative, it is necessary to divide the circle to be permitted on the enlargement by the degree of enlargement needed; if D is the diagonal of the enlargement, and d that of the

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negative, the degree of enlargement will be D/d. The above formula now becomes :—

$$H = \frac{f^2}{nC} \times \frac{D}{d}$$

Where C is now the circle of confusion to be permitted on the enlargement. Once again, all quantities must be in the same units.

If we accept the convention that the circle of confusion may be $\frac{1}{100}$ in. in the largest print likely to be viewed in the hand, and measure the focal length of the lens and the diagonal of the negative both in inches, the formula becomes :—

$$H = \frac{f^2}{nd} \times \frac{100D}{12} \text{ ft.}$$

The value of the factor $\frac{100D}{12}$ now depends only on the size of enlargement. Putting k for $\frac{100D}{12}$, we find the following figures for k, according to the size of print to be made :—

Size of Print.	*k.*
12 × 10 in.	130
10 × 8 in.	108
8½ × 6½ in.	89
7 × 5 in.	72
6½ × 4¾ in.	67

The formula for hyperfocal distance then simplifies down to

$$H = \frac{kf^2}{nd} \text{ ft.,}$$

and k is simply regarded as a figure to be adjusted to give whatever standard of definition we require. It is to be noted that in using the above formula we are making automatic allowance for the extra enlargement required by a smaller negative, and hyperfocal distances calculated from it are such that a contact print from a whole-plate negative, and whole-plate enlargements from a 3 × 4 cm. miniature negative, will show the same falling-off of definition at the hyperfocal distance.

The formula just given can be applied to every case, including that of a lens of exceptionally long or exceptionally short focal length for the size of negative made. In all ordinary cameras with one non-interchangeable lens, the focal

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length of the lens fitted is about equal to the diagonal of the negative. For such cases the even simpler formula

$$H = \frac{kf}{n} \text{ ft.}$$

may be used. It is used as the basis of the table of hyperfocal distances at the end of this article.

Another convention not infrequently adopted in finding the hyperfocal distance is to assume that the degree of enlargement used will in all cases be such as to give a print which, viewed at 10 inches, will correctly reproduce the perspective of the original scene. To satisfy this condition, the degree of enlargement must always be $10 \div f$, where f is the focal length, in inches, of the lens used to take the photograph. If the circle of confusion permitted on the enlargement is 1/100th inch, that on the negative will then be $f/1000$, and the formula for hyperfocal distance becomes :

$$H = \frac{1000f}{n}$$

where H and f are both in the same unit, which may be inches, feet, centimetres, or any other unit preferred.

For calculation it is more convenient to assume a circle of confusion, on the print, of 1/120th inch., making the formula $H = 1200f/n$ inches, or

$$H = \frac{100f}{n} \text{ feet.} \quad (f \text{ in inches})$$

This, it will be observed, is practically identical with the formula $H = kf/n$ given above, but it is now taken to apply to *every* case, and not only to those where the focal length of the lens is equal to the diagonal of the negative.

Note that the " correct perspective " formula implies that whole-plate prints will habitually be made from quarter-plate negatives taken with a 5–inch lens, but that if a 12-inch. telephoto is put into the camera in place of the usual lens, the final print will be made by *reduction* instead of enlargement, and will have a size of about $3\frac{1}{2} \times 2\frac{3}{4}$ in. It it is considered likely that the print will still be made by enlargement to whole-plate size, the formula $H = kf^2/nd$, as given above, will be the correct one to choose.

Besides marking the nearest point in focus when the camera is focused on infinity, the hyperfocal distance is the first figure required in making out a depth of focus table. (See DEPTH

Hyperfocal Distance in Feet

		Stops																					
F/Nos. English Series		1·4		2		2·8		4		5·6		8		11		16		22		32			
F/Nos., Continental Series			1·6		2·2		3·2		4·5		6·3		9		12·5		18		25		36		
Focal Length																							
cm.	in.																						
3·5	1⅜	ft. 106	ft. 93	ft. 74	ft. 68	ft. 53	ft. 46	ft. 37	ft. 33	ft. in. 26 0	ft. in. 23 6	ft. in. 18 6	ft. in. 16 6	ft. in. 13 3	ft. 12	ft. in. 9 3	ft. in. 8 3	ft. in. 6 9	ft. in. 6 0	ft. in. 4 8	ft. in. 4 2		
5	2	152	133	106	96	76	66	53	47	37 6	34 0	26 6	23 6	19 3	17	13 3	11 9	9 8	8 6	6 8	5 11		
7·5	3	228	200	160	145	114	100	80	71	57 0	50 0	40 0	35 6	28 6	25	20 0	17 3	14 0	12 6	9 9	8 9		
10·5	4⅛	320	279	224	204	160	140	112	100	80 0	71 0	56 0	50 0	40 0	36	28 0	25 0	20 0	18 0	14 0	12 6		
11·4	4½	348	304	244	222	175	155	122	108	87 0	78 0	61 0	54 0	43 0	39	30 6	27 0	21 6	19 6	15 3	13 6		
12·7	5	—	—	270	246	193	170	135	120	96 0	86 0	68 0	60 0	48 0	43	34 0	30 0	24 0	21 6	17 0	15 0		
13·5	5⅜	—	—	288	262	206	180	144	131	103 0	92 0	72 0	66 0	52 0	46	36 0	33 0	26 0	23 0	18 0	16 6		
14	5½	—	—	300	272	212	188	150	136	106 0	94 0	75 0	68 0	53 0	47	38 0	34 0	26 6	23 6	19 0	17 0		
15	6	—	—	320	286	228	200	160	143	114 0	100 0	80 0	72 0	57 0	50	40 0	36 0	28 6	25 0	20 0	18 0		
18	7	—	—	—	—	270	238	188	168	136 0	120 0	94 0	84 0	70 0	60	47 0	42 0	34 0	30 0	23 6	21 0		
20	8		—	—	—	308	272	216	192	154 0	136 0	108 0	96 0	77 0	68	54 0	48 0	39 0	34 0	27 0	24 0		
23	9	—	—	—	—	344	306	244	216	172 0	153 0	122 0	108 0	86 0	76	61 0	54 0	43 0	38 0	30 6	27 0		
25·4	10	—	—	—	—	380	340	272	240	190 0	170 0	136 0	120 0	95 0	85	68 0	60 0	48 0	43 0	34 0	30 0		
30	12	—	—	—	—	456	408	324	288	228 0	204 0	160 0	144 0	114 0	102	81 0	72 0	57 0	51 0	40 0	36 0		

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OF FOCUS.) In particular, it should be noted that if a lens is focused on the hyperfocal distance for the stop in use, objects are sharp from half the hyperfocal distance to infinity.

Table of Hyperfocal Distances.—The table of hyperfocal distances attached is calculated for the rather high standard of definition obtained by taking $k = 108$ in the above formula. It is the standard adopted by one of the leading makers of 35-mm. miniature cameras. If the highest standard of definition is not required, or if the lens in use is not capable of giving negatives yielding 10 × 8-inch enlargements that look as sharp as contact prints when examined at ten to twelve inches from the eye, it will be convenient to take for practical use a smaller figure for hyperfocal distance than is given in the table. This is most readily done by taking as the hyperfocal distance for any stop the figure given in the table for one stop smaller. (For example, the hyperfocal distance for a 3-inch lens at *f*/5.6 may be taken as 40 feet, the figure given in the table for *f*/8. This is equivalent to altering k from 108 to 76.5).

As it is impossible to allow in such a table for the use of a lens on negatives of different sizes, it is throughout assumed that the focal length of the lens is equal to the diagonal of the negative (*i.e.* $f/d = 1$). *This is approximately true in all cameras using a lens of "normal" focal length, and it is only to such cameras that the table applies.*

It does *not* apply to a lens used as a long-focus or wide-angle lens. In all such cases the hyperfocal distance given in the table must be multiplied by the ratio f/d. If, for example, a 13·5-cm. lens were used on a 3 × 4 cm. negative (diagonal = 5 cm.) the hyperfocal distance to be taken in practice is $\frac{13{\cdot}5}{5}$ or 2·7 times that given in the table. This allows for the much more precise focusing required on the small film as compared with the quarter-plate negative (diagonal = 5·35 in.) for which the focal length 13·5 cm. (5¼ in.) is "normal."

Finally, it may be emphasized that the figure calculated for hyperfocal distance need not be taken with too literal an exactness. A change in the standard of "sufficient sharpness" that would pass unnoticed in practical work would change the figure for hyperfocal distance quite considerably.

Hypersensitising. Any process used to enhance the speed of a plate or film is known as hypersensitising. Panchromatic

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material can be hypersensitised by immersing for about 5 minutes in :—

Alcohol (90 per cent.)	8 parts
Ammonia (0·880)	1 part
Water to	32 parts

The plate or film should be dried as quickly as possible in absolute darkness, and used within a few hours. The speed can often be doubled (increased by 3° B.S.) in this way, but there is a distinct tendency to fog.

Mercury vapour was at one time recommended for hypersensitising, the film being exposed for from 24 hours to 3 days to the vapour of mercury. This is most easily done by enclosing the film in a light-tight and practically air-tight container together with a drop or two of mercury. Roll film may be treated without unrolling ; the vapour penetrates the backing paper quite readily. The time of hypersensitising has, however, to be about doubled. It is specially noteworthy that mercury hypersensitisation may be applied to the exposed film, when it has at least as much effect as if the film had been hypersensitised before exposure. The effect of the treatment lasts for a week or two. Unfortunately results do not appear to be consistent ; some workers have found very large increases in speed, others at most a doubling, while others again have found that the treatment merely fogs the film. But it does seem to be established that hypersensitising by mercury, when successful, increases speed without in any way affecting colour-sensitivity, grain, or rate of development.

More reliable is a process of hypersensitising by light worked out in the Ilford laboratories (*Photographic Journal*, January, 1941). This depends on exposing the film, *after* it has received the exposure that is to form the picture, for a prolonged period to an exceedingly weak light. The colour of the light used is of no importance. The time of exposure to the fogging light is, however, a very important factor, and for the maximum effect it should not be less than about half an hour. The intensity of the fogging light must be cut down, by means of filters, coloured or of neutral tint as convenient, to such a level that the fog-density produced on development is of the order of 0·18 to 0·20.

The increase of speed is approximately four-fold (or six B.S. degrees) and though there is some falsification of tone values, the overall contrast is not much changed. Colour-rendering is unaffected.

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It is specially to be noted that exposure for a briefer time to a brighter light yields a much smaller increase in speed, and that exposure to a fogging light *before* making the main exposure, though it has often been advocated as a means of "overcoming the inertia," is totally ineffective.

Sulphur dioxide provides an effective, reliable, and easily-applied method of hypersensitizing specially suitable for amateur use. The exposed film is rolled into the tank-spiral in the usual way, and then, in a light-tight container such as a biscuit tin, the spiral is placed over an open vessel half-filled with a mixture, in equal parts, of ten per cent. solutions of (anhydrous) sodium sulphite and glacial acetic acid. The tin must be taped up to exclude light and retain the sulphur dioxide. After twenty-four hours' exposure to the vapour, the film is developed normally. The increase in speed attained amounts usually to a doubling or a little more.

Hypo. The common fixing salt used in photography, or a solution of it in water. "Hypo" is an abbreviation of "hyposulphite of soda," the name applied to the fixing salt early last century, when its constitution was not understood. This salt has long been known to be a thiosulphate. (See SODIUM THIOSULPHATE; also FIXING, ACID FIXING BATH, and HYPO ELIMINATOR.)

Hypo Eliminator. A chemical which destroys hypo, the intention being either to render prolonged washing unnecessary or to get rid of any traces of hypo that may still remain after a moderate amount of washing has been done.

The removal of all traces of hypo from a negative or print is commonly considered essential to permanence, and a great deal of endeavour has been directed at various times to achieving this end without the necessity for prolonged and tedious washing. There remains, however, no doubt that properly conducted washing, in running water or repeated changes, is the safest, if not the quickest, way of clearing negatives, on glass or film, of all the hypo they contain. (See WASHING.)

In case of need, the removal of hypo can be expedited by the use of an alkaline bath, which enables the hypo to diffuse more rapidly out of the gelatine. Although other alkalies will serve, ammonia is preferred as any remaining traces of it will evaporate from the negative on drying. After washing for 10 minutes in rapidly running water, the negatives are bathed for 3 minutes in a 0·3 per cent. solution of ammonia (1 part of 0·880

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ammonia to 100 parts of water), after which they should be washed again for two or three minutes.

Alternatively, but less desirably, the negatives may be washed in repeated changes of water made just pink with potassium permanganate (about 1 part to 25,000 parts of water) until the pink colour is no longer discharged.

It is now known that the paper, and possibly the baryta coating, of a print will retain hypo with such persistence that it is impossible to remove it completely by washing, no matter how prolonged. The amount so retained is small, but is sufficient to cause eventual fading in any gaslight or chloro-bromide print, and probably also in a double-weight bromide print, even though a bromide print, on account of its coarser grain, is less susceptible to the effects of hypo. A single-weight bromide print, which retains less hypo than one on double-weight paper, can be adequately freed from hypo by sufficiently prolonged washing.

To get rid of this retained hypo, it is necessary to destroy it chemically. This destruction, of course, results in the production of new sulphur compounds—usually thionates or sulphates—and it is necessary to ensure that these also are harmless to the image. It has been definitely established that an alkaline peroxide produces sulphate, which is harmless, and as a mixture of ammonia and hydrogen peroxide contains only substances that will volatilise away on drying the print, this combination should be used. A recommended formula (Kodak H.E.1.) is :—

Water	775 c.c.	(15½ oz.)
Hydrogen peroxide (10 vol.) .	125 c.c.	(2½ oz.)
Ammonia, 3 per cent. . .	100 c.c.	(2 oz.)

The 3 per cent. ammonia is prepared by diluting 1 part of 0·880 ammonia with water to make 10 parts.

Prints are washed for half an hour (double-weight prints for 1 hour) in water running fast enough to replace all the water in the washing-vessel once every five minutes. The prints are then immersed in the above eliminator for 6 to 8 minutes, washed again for 10 minutes, and dried. One litre (35 oz.) of H.E.1 will treat some twelve 8×10 prints, after which it should be discarded. (See also WASHING.)

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Image. In the optical sense, a reproduction of an object formed by a lens or mirror. Two types of image exist; the "real" image which can actually be received on a screen or a sensitive surface, and the "virtual" image which, though it can be seen by the eye or by a camera, cannot be received on a screen. The image in a "brilliant" finder or in a mirror is in this category.

In the photographic sense, "image" is often used in reference to the deposit of silver (or other substance) by which the picture is formed.

Image, Latent. An invisible image that can be revealed by development. An exposed but undeveloped film or print bears such an image.

Much research has been directed to the elucidation of the nature of the latent image and of the mechanism by which it is formed. It has been shown that the sensitivity of an emulsion depends largely on the presence of specks or nuclei of silver sulphide, and probably also of metallic silver, on the surfaces of the grains of silver halide. These nuclei are formed by the action of sulphur compounds present in the gelatine. Recent work has suggested that the light-quanta absorbed during exposure set free atoms of silver within the grain, and these atoms can move through the grain to the nucleus, so building it up until it is sufficiently large to enable development to take place. A more extended account of the Mott and Gurney theory will be found in the Twelfth Hurter and Driffield Memorial Lecture (*Photographic Journal*, February, 1941, page 63). This paper also contains a brief bibliography of the subject, while a very full summary of the whole problem will be found in *The Theory of the Photographic Process*, by C. E. K. Mees.

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Indiarubber Solution. This is used for edging plates or as a substratum for the collodion process, and also for mounting prints. Pure unvulcanised indiarubber (sold as masticated rubber or "cut sheet") may be dissolved in benzene, chloroform, or carbon disulphide, the two former being preferable, to make a 2 per cent. solution.

Induction Period. Time elapsing between the application of a developer to an exposed emulsion and the first appearance of the image.

Inertia. The exposure corresponding to the point where the straight part of the characteristic curve of an emulsion, produced downwards, cuts the axis of exposure. It is the figure upon which the H & D speed of the emulsion is based. (See SENSITOMETRY.)

Inertia, Regression of. Reduction of inertia, corresponding to increase of H & D speed, as development is more and more prolonged, This is behaviour characteristic of an emulsion, or a developer, containing free bromide. (See SENSITOMETRY.)

Infinity. In mathematics, a number larger than the largest that can be imagined, or, alternatively, a number whose reciprocal is indistinguishable from zero. Photographically, the setting of the focusing scale that gives a sharp image of an exceedingly distant object. For finding this setting experimentally, focus on an object the distance of which is not less than two thousand times the focal length of the lens divided by the *f*-number of its widest aperture.

See also HYPERFOCAL DISTANCE.

Infra-red Photography. Photography by means of infra-red "light." To this radiation, which differs from red light only in being of longer wavelength, the human eye is not sensitive, but it can be detected by virtue of the energy it carries, which is manifested as heat when infra-red radiation is absorbed.

Although invisible to the eye, infra-red light can be made to affect a plate or film by treating the latter with certain dyes, which is also the method used to render a plate sensitive to green, yellow and red light. These plates are meant for use only for photography in infra-red light, or by ordinary light

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in conjunction with a filter passing only infra-red. The following suggestions show some of the photographic uses to which this material can be put.

It is well known that the moisture vapour normally present in the air scatters red light less than blue light, and infra-red light still less. Dust has the same effect. If, therefore, we employ infra-red sensitive plates in conjunction with a lens-filter passing infra-red light only, we shall be able to penetrate haze much farther, and long-distance photography with a tele-photo or long-focus lens becomes comparatively easy. It is possible to take photographs in a room illuminated by means of infra-red light with high-power lamps and suitable filters, and, though the room is strongly lit with infra-red light, it is practically dark to the eye. In this case, of course, no filter is needed with the lens.

The most recent advances in sensitising plates for the infra-red have made it possible to photograph, in a darkened room or at night, by means of a flash-bulb fired in a reflector the front of which is covered by an infra-red filter. To the eye, the flash seems no brighter than a red dark-room lamp momentarily switched on, but if the flash is some eight to ten feet from the subject a fully-exposed negative will result if the lens is set at about *f*/4.5.

Some objects, such as foliage, dyed materials, etc., behave quite differently when illuminated by ordinary light and by infra-red light. Foliage, for instance, reflects the infra-red strongly, and hence appears dark on the negative and white on the print, so that trees, plants and fields when photographed in full sunlight appear as if covered with snow. This affords a valuable means of investigation by which natural or artificial differences between materials can be ascertained. Work on racial differentiation, investigation into spiritualistic phenomena, aerial photography, tissue penetration, etc., is in progress in various quarters.

Infra-red photography is also proving of great value in assisting in the deciphering of ancient documents not legible by the unaided eye, and in detecting forgeries, unauthorized erasions and the like.

It is most usual to employ an infra-red filter. This may be used in the form of gelatine film between the lens components, or as a sealed filter in front of the lens. As lenses are not normally corrected for infra-red light the focus is altered by this procedure, and it is necessary to scale the camera. Some help may be obtained by focusing with a red filter, such as the

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Ilford Tricolour Red, when an approximation to the correct position can be found.

The photographic technique is precisely the same as for panchromatic plates, except that it is possible to employ a brighter green safelight of suitable composition.

For further information, see *Photography by Infra-Red*, by Walter Clark.

(See also LIGHT.)

Ink Process. In the past several processes have been known under this name. The following is due to Lemling.

Prepare a 5 per cent. solution of potassium bichromate, and render it neutral by adding ammonia. In every three parts of this dissolve 1 part of gum arabic, and filter. Spread this solution evenly over a sheet of albumenised paper (*q.v.*) with the aid of a Blanchard brush. The paper should then be laid, film up, on a sheet of plate-glass, a good-sized pool of the solution poured on to it and made to cover it evenly, the excess poured off, and the paper hung up to dry. Expose behind a negative to daylight, the paper being then laid face downwards on water and allowed to soak for some time with repeated changing of the water, after which it is soaked in alum solution and again washed. It is then drawn over the surface of the following solution :—

Pyrogallol	1 part
Distilled water	50–80 parts

Or it may be floated on the solution for 2 minutes, then thoroughly washed and floated on

Ferrous sulphate	10 parts
Distilled water	100 parts

and again washed. If not dark enough the process may be repeated.

(See also DRAWINGS FROM PHOTOGRAPHS.)

Inks. *Indian Ink*, used in carbon printing and other similar process, appears to contain a special fine lampblack.

Ink for Writing on Celluloid.—Dissolve 10 gm. of ferric chloride in 25 c.c. of acetone, and 15 gm. of tannic acid in 75 c.c. of acetone, and mix the two. This forms a quick-drying black ink that may be used with any clean pen, and will write on celluloid without spreading or flaking off.

Ink for Writing on Glass.—Two parts of ordinary shellac is dissolved in 14 parts of methylated spirit, and strained

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through muslin ; and to this is added, a little at a time, and with agitation, a solution of 3 parts of borax in 24 parts of water. The pigment or colour used should be mixed in with the borax solution ; Indian ink or any finely ground water colour being suitable.

Indestructible Ink for Labels.—As above, with Indian ink as pigment.

White Ink for Lantern Slides.—Chinese white, gum, and water to suitable consistency.

The term "Ink" is also applied to the pigments employed in the oil-pigment and bromoil processes (*q.v.*).

Instantaneous Photography. An old term applied to photography of any kind of subject taken by an "instantaneous" or snapshot exposure, but perhaps more particularly to the photography of moving objects. Since practically all amateur work is now done with "instantaneous" exposures, the term has long since lost its specialised meaning. (See CAMERA ; MOVING OBJECTS, PHOTOGRAPHY OF ; FLASH-GUN ; SHUTTER.)

Instantaneous Shutters. See SHUTTER.

Institute of British Photographers. This is an association open only to those professionally engaged in any field of photography. Its policy is to raise the standards of the profession, establish recognized qualifications and a high standard of conduct, and to safeguard the interests of the profession and its members. Formed on 28th March, 1901, in Fleet Street, London, it was known as the Professional Photographers' Association and the first president was Thomas Bedding, F.R.P.S., Editor of *British Journal of Photography*. Work in connection with the 1911 Copyright Act and the first Press fees agreement negotiated with the Newspaper Proprietors Association, Newspaper Society and Scottish Newspaper Society were two of its earlier achievements. In 1938 the name was changed to Institute of British Photographers and the professional qualifications of Fellowship and Associateship established entitling those who gain them to use the letters F.I.B.P. or A.I.B.P. The Institute acts through local centres throughout Britain. Headquarters, 38, Bedford Square, London, W.C.1.

Intaglio Process. See PHOTO-MECHANICAL PRINTING PROCESSES.

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Integral Tripack. Type of colour film coated with three independent emulsions. All subtractive colour films, negative or reversal, are of this type. See COLOUR PHOTOGRAPHY.

Integrating Meter. Type of exposure meter (*q.v.*) used by pointing it at the subject as a whole, so that it measures its average brightness.

Intensification. Any process by which the intensity, actual or effective, of the photographic image can be increased. The usual methods depend on adding further material to the image already present, and the process is ordinarily applied to negatives in which the contrast is insufficient.

Lack of contrast may be (*a*) general, throughout all tones, or (*b*) restricted largely to the shadow regions of the picture. Case (*a*) is representative of under-development, and the chromium intensifier is now the usual remedy. It is both reliable and effective. Case (*b*) is typical of slight under-exposure, and though there is no complete remedy, the uranium intensifier, which intensifies the shadows more rapidly than the half-tones and highlights, is more effective than any alternative treatment.

Intensification and its opposite, reduction, were freely resorted to at one time, but now that most papers are available in several contrast-grades it is no longer necessary to adjust the contrast of the negative to suit the paper. Instead, the paper is chosen to suit the negative, and intensification is in consequence but rarely required.

A negative to be intensified must be fully fixed, for any unused silver compounds that may remain will be intensified along with the image. It is very desirable to re-fix the negative in fresh hypo and to wash thoroughly before intensification by any process is attempted.

Chromium Intensifier.—This is one of the simplest and most controllable processes of all, and has the advantage that small traces of hypo remaining in the negative are harmless. It can be used also to darken bromide prints that are too light.

A.	Potassium bichromate .	1 oz.	(50 gm.)
	Water to . . .	20 oz.	(1000 c.c.)
B.	Hydrochloric acid . .	2 oz.	(100 c.c.)
	Water to . . .	20 oz.	(1000 c.c.)

The negative or print is first bleached in a mixture of A and B, the proportions taken depending on the amount of intensification desired. Intensification is greatest when the

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amount of B is so small that bleaching is very slow, and decreases as more B is used. For use A is diluted with six times its volume of water, and an amount of B varying from one-quarter to four times the amount of A is added.

When the negative or print is fully bleached a yellow-buff image remains, but there is no black in it. The bulk of the yellow stain is washed out with successive changes of water, and the final traces removed by one or two successive baths of a dilute (about 1 per cent.) solution of potassium metabisulphite. After two more changes of water, the image is exposed to diffused daylight or bright artificial light, and redeveloped in a developer containing a minimum amount of sulphite. A fine-grain developer is unsuitable, as the sulphite in it will partially dissolve the bleached image.

If the first application of the process does not produce sufficient darkening, the negative or print may be intensified a second time. With bromide or gaslight prints, the colour obtained is normally a good rich black, and the process may be used (with much hydrochloric acid in the bleacher) to improve the colour of an otherwise satisfactory print.

Uranium Intensification.—This process, particularly valuable in cases of slight under exposure, depends on toning the image to a bright reddish-brown. It is a single-solution process, and should normally not be carried to completion, or the preferential action on the shadows will be lost.

The following is the Ilford formula, and requires two stock solutions :—

A.	Uranyl nitrate. . .	220 gr.	(25 gm.)
	Water to . . .	20 oz.	(1000 c.c.)
B.	Potassium ferricyanide .	220 gr.	(25 gm.)
	Water to . . .	20 oz.	(1000 c.c.)

For use, take 4 parts each of A and B, and add 1 part of glacial acetic acid.

In this mixture the negative rapidly becomes more opaque and brownish in colour. When intensification is sufficient, the negative is washed in successive changes of *still* water to remove the yellow stain. It is advisable to make the wash-water slightly acid by the addition of a trace of acetic acid, as tap water, which is usually faintly alkaline, will dissolve the intensification.

If intensification has been carried too far, the negative can be restored to its original condition by treatment in weak

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sodium carbonate solution, followed, after washing, by immersion in any normal developer not of fine-grain type. After further thorough washing, intensification may be repeated.

Silver Intensification.—This process, originally due to J. B. B. Wellington, is similar in its action to physical development. (See FINE-GRAIN DEVELOPMENT.)

The silver intensifier is a proportional one, and neither changes the colour of the image nor affects its permanence. The following is the Kodak IN 5 formula. The working solution is made up at the time of use from four stock solutions. A and B are respectively 6 per cent. solutions of silver nitrate and sodium sulphite (anhydr.), C is a 10½ per cent. solution of hypo (crystals), and D consists of:—

Sodium sulphite (anhydr.) .	44 gr.	(5 gm.)
Metol	70 gr.	(8 gm.)
Water to	20 oz.	(1000 c.c.)

To make up the working solution, add 1 part of B slowly to 1 part of A, stirring continuously. The white precipitate that appears is then dissolved by adding 1 part of C, and the mixture allowed to stand for a few minutes to clear. Then, again with stirring, add 3 parts of D. The film to be intensified should be immersed in the solution at once, and left until the image is sufficiently strengthened. If, after 25 minutes, the image is still not strong enough, the intensifier should be discarded and replaced by a fresh supply.

After intensification, immerse the film for two minutes, with agitation, in plain 30 per cent. hypo solution, and finally wash well.

It is essential that all dishes used should be scrupulously clean, and intensification should be done in artificial light, not strong daylight.

Mercury Intensification.—In the usual form of this process the negative is first bleached in an acidified solution of mercuric chloride, after which it is darkened in any one of a number of darkening agents, according to the degree of intensification desired.

An Ilford formula for the bleacher is:—

Mercuric chloride . .	220 gr.	(25 gm.)
Potassium bromide . .	220 gr.	(25 gm.)
Water to	20 oz.	(1000 c.c.)

The well-washed negative is bleached right through in the above solution, washed well, and then blackened in either a

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10 per cent. solution of (anhydr) sodium sulphite, a standard print developer, or a mixture of one part of 0·880 ammonia with 100 parts of water. The sulphite gives least, the ammonia the greatest, intensification. If developer is used for darkening, the process may be repeated if desired to give stronger intensification, and it has been stated that if an amidol developer is used the intensification is proportional—that is, it involves no falsification of tone-values.

For very heavy intensification Monckhoven's formula may be used for blackening:—

A.	Silver nitrate . .	350 gr.	(40 gm.)
	Distilled water . .	20 oz.	(1000 c.c.)
B.	Potassium cyanide . .	350 gr.	(40 gm.)
	Distilled water . .	20 oz.	(1000 c.c.)

Add B gradually to A, shaking well after each addition, till only a small quantity of the whole flocculent precipitate remains. It is important that this should not all be redissolved. This solution attacks shadow detail and should therefore only be used for the intensification of line subjects.

Special Note. Before handling cyanide, refer to POISONS.

An alternative darkener, giving much the same degree of intensification but not involving the very poisonous cyanide, is the following:—

Sodium thioantimonate (Schlippe's salt) . .	220 gr.	(25 gm.)
Ammonia (0·880) . .	120 min.	(12·5 c.c.)
Water	20 oz.	(1000 c.c.)

This gives a bright reddish-brown negative. A 1 per cent. solution of sodium sulphide gives a very similar result, though as the colour is less warm, the effective intensification is not so great.

Mercuric Iodide Intensifier.—A single-solution mercury intensifier can be made up as follows (Lumière formula):—

Sodium sulphite (anhydr.) .	880 gr.	(100 gm.)
Mercuric iodide . . .	90 gr.	(10 gm.)
Water	20 oz.	(1000 c.c.)

Dissolve in order, and keep in the dark. In this solution the image gradually gains in intensity; the action can be watched and stopped at any desired stage. Thorough elimination of hypo before intensification is not necessary. An intensified

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negative is not very permanent, but may be made so by treating for a short while in any non-staining developer or by immersion for a few minutes in 1 per cent. sodium sulphide solution. Unless treated in one of these ways, the intensification may all be removed by treatment with 40 per cent. hypo solution. Owing to the fact that the shadows are intensified more than the high lights, this process is particularly valuable in cases of slight under-exposure.

Copper Intensifier.—This process gives very great intensification, and is suitable for line subjects or ordinary negatives on which the image is a mere ghost.

A.	Copper sulphate . .	90 gr.	(10 gm.)
	Acetic acid (glacial) .	540 min.	(56 c.c.)
	Water to . . .	20 oz.	(1000 c.c.)
B.	Potassium iodide . .	90 gr.	(10 gm.)
	Ammonia (0·880) . .	1 oz.	(50 c.c.)
	Water to . . .	10 oz.	(500 c.c.)

The negative is bleached in A, 2 parts; B, 1 part; on mixing the solution develops heat; it should not be used till cool. The mixture should be faintly acid; if it will not turn blue litmus paper faintly red, add more acetic acid until it does. The solution is perfectly stable and can be used repeatedly till exhausted.

The bleached negative must be washed for 20 minutes in running water. It should then be hardened in alum or formalin, washed, and darkened in :—

Silver nitrate . . .	22 gr.	(2·5 gm.)
Sodium acetate . . .	90 gr.	(10 gm.)
Water	20 oz.	(1000 c.c.)

After washing, the negative is soaked for 2 minutes in a 1 per cent. solution of ammonia, rinsed, and finally darkened in a solution of sodium hydrosulphite or in an amidol developer made alkaline by the addition of a little sodium carbonate.

Lead Intensifier.—Like the copper intensifier, this gives very great increase in density. Bleach in the following (Callier formula) :—

Potassium ferricyanide . .	360 gr.	(40 gm.)
Lead nitrate	520 gr.	(60 gm.)
Acetic acid (glacial) .	180 min.	(18·7 c.c.)
Water to	20 oz.	(1000 c.c.)

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Intensifying Lantern Slides and Prints

After bleaching, pass through three or four successive baths of 3 per cent. hydrochloric acid, allowing 5 minutes in each. Then wash till the image is white, and darken in a weak solution (about 1 per cent.) of ammonium sulphide.

Intensification by Toning.—The colour imparted by the ordinary sulphide toning process will add to the effective density of a negative. Bleach in :—

Potassium ferricyanide .	. 440 gr.	(50 gm.)
Potassium bromide .	. 440 gr.	(50 gm.)
Water	. 20 oz.	(1000 c.c.)

Wash till free from stain, and darken in a 1 per cent. solution of sodium sulphide. Wash and dry. It is worth noting that this process is particularly suitable for miniature negatives, as it does not coarsen the grain.

Local Intensification.—Any intensifier can be applied locally by means of a brush. The work is best done on a retouching desk, and the application of bleacher and redeveloper must be watched carefully so that the former does not run on to other parts of the negative. Local treatment of this kind can also be carried out successfully by painting an acid-proof varnish over all parts of the negative not requiring intensifying, and then treating the entire negative with the intensifier.

Intensifying Lantern Slides and Prints. Practically all the above methods of intensification can be applied to lantern slides as well as negatives. Bromide and gaslight prints can also be intensified by the methods of bleaching and redevelopment given above. (See also TONING.)

Intensity Scale. In making a series of known exposures on a sample of film, these exposures may be (*a*) made to light of constant intensity, but for different times or (*b*) made all for the same time, but to light of different intensities. The first gives a "time scale" of exposures, the second an "intensity scale." Owing to the fact that the reciprocity law (*q.v.*) is not exactly obeyed by photographic materials, the two types of scale give different results. The ordinary test-strip, made by exposing for 1, 2, 4, 8 . . . etc. seconds, is made on a time scale, while a strip of film or paper exposed under a step-wedge is made on an intensity scale. Modern sensitometry is based on an intensity scale, which more nearly reproduces the conditions of practical photography.

Interchangeable Lenses. Lenses designed, or mounted, so that they can be used interchangeably in the same camera.

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If the camera has a focal-plane shutter almost any lens, if mounted in an extension tube of the correct length, can be adapted; the main limitations are that it may be mechanically impossible to fit a lens of very short focus (unless of retrofocus, or reversed telephoto, design) and the opening in the front panel of the camera may be small enough to produce vignetting with lenses of very long focus.

Interchangeable lenses are less easy when the shutter is mounted immediately behind the lens; vignetting is inevitable unless the back glass of the lens is very close to the shutter. This means that long-focus lenses must necessarily be of telephoto type, and must have exactly the right back focus for the camera with which they are to be used. This style of mounting also limits focusing range; vignetting appears if the lens is moved too far forward for focusing on near objects.

Effective interchangeability has also been secured by a special design of lens, with one component in front of and one behind the shutter; to change focal length the front component is removed and replaced by another. The need to keep the focal plane (location of sharp image) and the f-number of the stop strictly unchanged means that the supplementary components giving long or short focus have to be rather complex in design.

Interiors. See ARCHITECTURAL PHOTOGRAPHY.

Interlock. A mechanism fitted to all but inexpensive film cameras; it prevents the film from being wound on till the shutter has been released, and also prevents the shutter from being released a second time till the film has been wound on. In this way automatic protection is given against both double exposure and blanks.

Intermittency Effect. If an exposure is given in a number of brief instalments the resulting density is not usually the same as that which would be given by an equal amount of light energy in one continuous exposure. The effect produced by an intermittent exposure lies between those produced by two nominally equivalent continuous exposures, one of short duration and intensity equal to the flash period of the intermittent exposure, and the other of longer duration and intensity equal to the average intensity of the intermittent exposure. The effect is a manifestation of the failure of the reciprocity law.

For further details, see *The Theory of the Photographic Process*, by C. E. K. Mees.

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Inverse Squares, Law of. If a surface is illuminated by a point source of light, the intensity of illumination at the surface is inversely proportional to the square of its distance from the light. If at 1 ft. from a lamp an exposure of 10 sec. is necessary in making a bromide print by contact, the exposures needed at 2, 3 and 4 ft. from the lamp will be 40, 90, and 160 sec. respectively.

This law only holds for undirected light—*i.e.*, in the absence of any reflector or condenser. For directed light, the rate of diminution of intensity with increasing distance depends on the rate of divergence of the beam. For a parallel beam, as of a searchlight, intensity is the same at all distances except for absorption by the intervening air.

Inverted Telephoto. Lens with a negative front component and a positive back component, giving a back focus considerably in excess of the equivalent focal length. (Compare TELEPHOTO LENS.) The most usual purpose of this construction is to provide a wide-angle (short-focus) lens that can be used on a single-lens reflex without fouling the mirror.

Invisible Rays. Term sometimes applied to radiations, such as infra-red or ultra-violet light, whose wavelength falls outside the visible spectrum. (See also RADIOGRAPHY.)

Iodine. (Fr., *Iode ;* Ital., *Iodio ;* Ger., *Jod* or *Iod*). I = 127. One of the halogen elements. Is obtained from Chile, and appears commercially in metallic bluish-grey scales. Solubility : 1 in 7000 of water, 1 in 12 of alcohol, 1 in 4 of ether ; very soluble in a solution of any alkaline iodide. One part of iodine and 1 part of potassium iodide will dissolve in 2 parts of distilled water. The element itself is of less photographic use than its compounds, but finds a place occasionally in bleachers or reducers.

I.R. Abbreviation for "infra-red." (See LIGHT.)

Iris Diaphragm. See DIAPHRAGMS.

Iris Mount. Term used to describe a lens-mount in which the thread for the flange is at the back of the lens, so that the lens projects considerably from the lens-panel. The incorporation of an iris diaphragm is, of course, taken for granted.

Iron Printing Processes. See AMPHITYPE, CYANOTYPE, INK PROCESS, KALLITYPE, PLATINOTYPE and SEPIA PAPER.

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Iron Salts. The following will be found under their respective names :—

Ferric ammonium citrate. Ferric chloride.
Ferric ammonium oxalate. Ferrous oxalate.

Ferric ammonium sulphate (iron alum) will be found under ALUM.

Irradiation. Spreading of light in an emulsion during exposure. If a photograph is taken of a small bright object against a dark background, the image of the bright object, falling on the white opaque surface of the film, acts during exposure as a secondary light-source, reflecting and scattering light into neighbouring parts of the picture. In large-scale photography the effect of irradiation is negligible, but in cinematography or miniature-camera still photography the scattered light can cause an appreciable loss of sharpness. It is liable to occur wherever there is violent contrast between light and dark, and is accentuated by too generous an exposure. As can be seen, the thicker the emulsion layer on the film the greater the scattering effect of a brightly-lit image. Special " thin-film " films, of moderate speed and high resolution, are available for miniature camera work. (See BEUTLER METHOD.) The reversal emulsions used for amateur cinematography are also thinly coated. (See also HALATION.)

Isochromatic. Synonymous with ORTHOCHROMATIC, *q.v.*

Ivory. The teeth and tusks of the elephant and walrus. Photographs can be obtained on ivory by coating with an emulsion, or by transfer as in the carbon process. Various artificial substitutes have been used, such as insoluble gelatine or celluloid containing a white pigment.

Ivory Black. Made by calcining ivory in closed crucibles. Used as an ingredient for black varnish and as a pigment.

Ivorytype, or Eburneum Process. Terms which have been applied to several photographic processes in which the positive or print is on a surface resembling ivory. In one method, a carbon or collodion transparency was produced upon a plate of waxed glass, and the glass being levelled with the positive uppermost, the following mixture was poured on :—Gelatine, 10 parts in 40 parts of water ; melt and stir in 2 parts of zinc white and 1 part of glycerine. When the gelatinous film is dry the edges can be cut round with a knife, and the whole stripped from the glass.

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J

Japanese Tissue. A Japanese paper or vellum having a fibrous unsized surface and requiring little preparation for photographic use. It can be employed as a base for silver, carbon, carbro, gum, and oil or bromoil transfer prints with considerable success. It is also very suited for etching, wood-block printing and photogravure.

Jelly for Enlarging Easel. It is convenient to coat the easel of a horizontal enlarger with a jelly to which the paper will adhere during exposure. The jelly used for "jellygraph" duplicators, which can be bought ready prepared, is usually effective. A similar preparation can be made by putting 1½ oz. (57 gm.) of leaf gelatine to soak in water overnight in a jam pot. In the morning pour off the water, pour in 8 oz. (320 c.c.) of glycerine, stand in a saucepan of water and heat up till dissolved. Stir in a few drops of oil of cloves to act as preservative, and pour the solution into a flat metal tray to set. This gives a smooth surface to which paper will adhere on being firmly rubbed down with the hand or a clean cloth.

Jena Glass. See GLASS, and LENS.

Joule. Unit of electrical energy. If one watt of power is expended for a period of one second, the energy expended is one watt-second, or one joule. Electronic flash (*q.v.*) equipment is commonly rated in joules, the quoted figure being the electrical energy available for each flash.

Judging Distances. See HAND CAMERA WORK.

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K

K.—Temperatures are often expressed in degrees of the Kelvin scale; thus, 3000° K. This scale, named after Lord Kelvin, is the same as the Absolute scale (*q.v.*).

Kallitype. A printing process invented by W. W. Nicol, the principle of which is that ferric salts are reduced by light to ferrous, and in this condition can reduce to the metallic state a soluble silver salt. The kallitype process is based on the same reactions, and involves much the same methods of working, as the better-known platinotype process. The only fundamental difference between the two is that in kallitype the final image is in silver instead of platinum. Platinotype was at one time famed for the beauty of the results obtainable, and in this respect kallitype does not fall behind. The silver image, however, cannot claim the extreme permanence of one composed of platinum, but it is probable that a properly-made kallitype print would at least be no less permanent than one on P.O.P. or self-toning paper.

The sensitising solution consists mainly of ferric oxalate, which is reduced by light to the insoluble ferrous oxalate. If this is dissolved, in presence of silver nitrate, in a suitable solvent, the ferrous salt in turn reduces the silver nitrate to metallic silver, so forming the image. This process is termed development. The silver nitrate may be part of the developer, but it is more economical to incorporate it in the sensitising solution.

Contrast and colour can both be controlled by modifications in the sensitising solution and the developer, and to a further extent by the depth of printing. In addition, the colour of the finished print can be further modified by toning by any of the principal processes used for P.O.P. Any good quality paper, if it will stand up to immersion in water for an hour or two without becoming too soft, will be satisfactory. Drawing paper

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is perhaps best, or a smooth paper intended for water-colour work. Cartridge paper is also perfectly suitable, while for experimental work ordinary unruled writing-paper serves well. Whatever paper is used, it should be sized to prevent the sensitising solution from sinking into the fibres.

Arrowroot or starch size is the easiest to apply, but must always be freshly made. 200 grains (20 gm.) of starch or arrowroot is rubbed into a paste with a little cold water, and then 20 oz. (1000 c.c.) of boiling water is poured on to it. The mixture is boiled till it becomes clear (one or two minutes), strained through muslin and left to cool. The paper is either floated on this solution for one minute or immersed in it for two, then hung up to dry.

If the paper is floated, be careful it is face down. Most papers have a sieve-like pattern in faint relief on one side ; this is the back, and if coated on this side the pattern may show on the finished print.

The fundamental chemical used for sensitising, ferric oxalate, must be free from ferrous salts and from organic impurities such as dust. It should give a clear amber solution with water, and when tested by adding a few drops of potassium ferricyanide solution to a sample, no trace of blue colour should result. The ferricyanide itself must be pure for the test ; choose a fair-sized crystal and wash all surface crust away under the tap before dissolving it.

Even if we restrict ourselves to the type of paper in which the whole of the silver is included in the sensitising solution, there nevertheless remain very many sensitising formulæ to choose from. That given here is simple but reliable, allowing considerable variation in contrast and colour to be obtained by modification of the developer.

The following sensitising solution is prepared, preferably in a dim light :—

Ferric oxalate . . .	4½ oz.	(225 gm.)
Potass. oxalate (neutral) .	500 gr.	(55 gm.)
Silver nitrate . . .	500 gr.	(55 gm.)
Water to	20 oz.	(1000 c.c.)

Distilled water should be used if possible, and the mixture should be kept in the dark.

The paper, sized as described, is pinned, face up, on a board in a warm and dimly-lighted room. With a broad soft brush a small amount of the sensitiser is spread, evenly but very lightly, over the paper. There must be no attempt to rub the

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solution into the paper; on the contrary, every effort must be made to keep it on the surface. About 30 to 40 minims (2 to 2½ c.c.) is wanted for a 12 × 15 in. sheet. As soon as the coating is surface-dry, finish the drying quickly by gentle heat, being careful that the paper is not made hotter than the hand can comfortably bear. When fully dry, the paper should crackle when shaken.

Printing is done by daylight, and is continued till the outlines of the shadows are distinctly visible, but not long enough to show more than the faintest tint in the middle tones.

For developing the exposed print is immersed in, or floated on :—

Borax	1 oz.	(50 gm.)
Rochelle salt . .	525 gr.	(60 gm.)
Water to	20 oz.	(1000 c.c.)

As a restrainer, very effective in increasing contrast and keeping the whites pure, a 2 per cent. solution of potassium bichromate is added. A normal dose is 30 minims per ounce of developer (6 c.c. per 100 c.c.) but the amount may be varied within very wide limits.

The above developer gives black or brown-black tones; for warmer tones, reduce the quantity of borax and increase that of Rochelle salt. Greater control over colour is obtained by replacing the potassium oxalate in the sensitiser by 20 gr. (2 gm.) of oxalic acid. The developer is then used at double strength. The print should remain in the developer for at least 10 minutes.

Rinse well after development, and fix for 5–10 min. in 3 per cent. hypo made slightly alkaline with ammonia. Wash, blot off surface moisture, and dry, using gentle heat if desired.

If desired, the finished print may be toned in any of the solutions suggested (see TONING) for printing-out papers.

Kata-Positive. A term occasionally used to distinguish a positive on an opaque base from a *diapositive* or transparency.

Kelvin. For degrees Kelvin, see ABSOLUTE TEMPERATURE.

K Filters (or Screens). A certain kind of commercial yellow filters for use with orthochromatic and panchromatic emulsions; they are made with a dye known as "Filter Yellow K." (See FILTER.)

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Kilo-. Prefix used in the metric system (*q.v.*) to signify "one thousand." For example, a kilogram is a thousand grams.

Kinetoscope, Kinematograph. See CINEMATOGRAPHY.

Kodachrome. Process of colour photography introduced by Kodak Ltd. It is a dye process yielding transparent and grainless positives on film. For details, see CINEMATOGRAPHY and COLOUR PHOTOGRAPHY.

Kodacolor. The name (*a*) of an obsolete Kodak process of colour cinematography using lenticulated film, and (*b*) of a current Kodak negative-positive process giving colour prints on paper. After exposure, the film is returned to the makers, where it is processed to give negatives in colours complementary to those of the subject. From the negatives, prints in colour are made by projection. See COLOUR PHOTOGRAPHY.

Kodak. A registered trade-mark of Kodak, Ltd., applied by them to various goods of their manufacture, notably cameras.

Kodatron. Electronic flash unit of Kodak manufacture. See ELECTRONIC FLASH.

Kodalk is an alkali usually stated to be sodium metaborate ($Na_2B_2O_4 8H_2O$, M.W. 276), introduced by Kodak Ltd., for use as accelerator in certain types of negative developers. It is intermediate in activity between sodium carbonate and borax and is claimed to possess a number of advantages over these compounds. It is a stable, crystalline compound which does not cake when added to water and does not release a gas when added to an acid fixing bath. It requires no greater care in handling than sodium carbonate and is suitable for compounding moderately active developers.

Further, with increasing concentrations of this alkali, the activity of an M.Q. developer does not change as rapidly as when carbonate is used, so that it is possible to control the activity of a weakly alkaline developer with precision by varying the concentration of Kodalk.

According to a Kodak patent specification, sodium metaborate is prepared by fusing together 20 parts of borax and 4·2 parts of sodium hydroxide.

Solubility: 100 parts of saturated solution contain 23 parts of Kodalk at 40° F., or 33 parts at 70° F.

Kodurol. Trade name for glycin sold by Kodak Ltd.

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Labels. The need for labels to identify his various bottles of chemicals and solutions becomes obvious to every photographer who attempts more than the very simplest work. Unless waterproofed, labels are liable to come away in the damp air of the darkroom, and they also soon become disfigured by drops of developer or other liquid that may run down the outside of the bottle. Cleanliness in the darkroom is greatly assisted by using waterproof labels, for any bottle the outside of which has become contaminated with solution may be held under the tap before being replaced on the shelf.

Gummed paper is usually more convenient than ready-made labels; a sheet of "gum demy" will provide material for labelling many bottles. Waterproof ink can be obtained from an artist's supply stores, but if the labels are to be proofed after affixing to the bottles ordinary ink will do equally well.

After cutting out a label of the required size and writing on it the desired name (and formula, if of a mixed solution), the ink should be given time to dry thoroughly. Damp the back of the paper with a moist rag or sponge, lay on the bottle, cover with a clean piece of paper, and rub down. When dry, varnish with any commercial celluloid varnish or adhesive, with a varnish made by dissolving celluloid in amyl acetate, or with a solution of paraffin wax in xylene.

Lambert. Unit of brightness, or of the amount of light given off by unit area of a surface. A surface that emits one lumen of light per square centimetre has a brightness of one lambert.

The lambert is a most convenient unit for describing the brightness of flames or incandescent bodies, but is inconveniently large for describing the brightness of any part of the usual photographic subject. In photographic work brightness is usually expressed in lumens per square metre.

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A brightness of 10,000 lumens per square metre is equal to one lambert.

See LUMEN, CANDLE-POWER, CANDELA, LUX. Also ELECTRIC LIGHT.

Lampblack. The very light form of carbon produced by burning pitch, resin, or any other smoky substance with limited access of air, and collecting the soot formed.

Lamp for Dark-Room. See DARK-ROOM, also SAFELIGHT.

Landscape Lens. See LENS.

Landscape Photography. The general principles of landscape photography, embodying as they do the rules underlying all picture-making, can hardly be made the subject of a dictionary article, but reference to PICTORIAL COMPOSITION will offer suggestive lines to be followed. From the practical standpoint the apparatus most suitable for serious landscape work is either a stand or reflex camera with long extension, equipped either with a convertible lens or with two or more interchangeable lenses of different focal lengths. Cameras with viewfinders are in general less satisfactory except in very experienced hands, as the ability to examine the full-size image on the screen is of more assistance in landscape work than in almost any other branch of photography, save perhaps architecture. A colour filter should be used if the colour values of the scene are to be translated correctly in the photograph. (See FILTER and COLOUR-SENSITIVE EMULSIONS; also CLOUD NEGATIVES, COMBINATION PRINTING, and ENLARGING.)

Lantern, or Optical Lantern. See PROJECTOR.

Lantern Slide Diagrams. Titles or diagrams for lecture purposes, or for showing results of elections, matches, etc., in the lantern can be quickly made in the following manner :—

(1) Write with black waterproof ink and a fine-pointed but not too hard pen on an ordinary lantern plate, allow the ink to dry thoroughly, and then fix out the silver in an ordinary hypo fixing bath, wash and dry. Stale or fogged plates can of course be used. (2) If preferred, write with waterproof ink on fine ground glass, then, when the ink is dry, coat the ground glass with any clear, hard-drying negative varnish. (3) Old plates cut down to $3\frac{1}{4} \times 3\frac{1}{4}$ in., and the silver dissolved

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out with strong ferricyanide and hypo reducer, leave plates covered with a film of plain gelatine. A number of these, prepared in advance, are always useful for writing on with pen and Indian ink. (4) " Smoke " a plain piece of glass in a candle flame and write on the smoked surface with a pointed piece of wood. (5) Type the notice on cellophane, tracing paper, or even thin typewriting paper, using a sheet of carbon paper (as used for duplicating) in such a way as to give a second impression on the back to reinforce the lettering. The notice may then be bound up between glasses.

Where it is desired to incorporate a diagram or printed matter, or a line drawing, in a series of slides, it is often preferable to project the negative rather than a positive from it. The dark ground so obtained avoids " dazzle " due to the large area of clear glass that in a positive would represent the white paper of the original. It is generally advisable either to keep the negative fairly thin, or, better, to tone it to a warm colour, the purpose in either case being to allow the lecturer's pointer to be seen more readily.

Lantern Slides. Lantern slides are small transparencies for exhibition by projection on to a screen. Three sizes are current, of which the best-known are the old " standard " slide of overall dimension $3\frac{1}{4} \times 3\frac{1}{4}$ in., and the immensely popular " miniature " slide of size 2×2 in. The newer $2\frac{3}{4} \times 2\frac{3}{4}$ in. slides, introduced for the user of colour films in the $2\frac{1}{4}$ in. square size, are still comparatively rare. Allowing space for binding and masking, the picture on the standard slide is usually $2\frac{1}{2}$ to $2\frac{3}{4}$ in. long at most, and is often smaller. On the miniature slide the picture-opening is generally 24×36 mm., though the " super-slide," with a picture-opening 4×4 cm., is rising in popularity. Continental Europe has a standard slide of outside dimensions 85×100 mm. ($3\frac{1}{3} \times 4$ in. approx.) with a maximum picture-area 75 mm. (3 in.) square. The standard size of slide in the U.S.A. is $3\frac{1}{4} \times 4$ in. ($82{\cdot}5 \times 101$ mm.) with a maximum picture area $3 \times 2\frac{1}{4}$ in. ($76 \times 57{\cdot}5$ mm.).

Making Standard Slides.

Printing by Contact.—Slides are made either by contact or projection. In the former case they are of course the same size as the negative, and when this, or the desired part of it, is the right size to give a picture of suitable dimensions, printing by contact is the most convenient method. An ordinary printing frame can be used, but there is considerable

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danger of scratching either negative or lantern plate in adjusting them to the required relative positions.

To avoid this, a special frame can be made from an ordinary printing frame decidedly larger than the negative. The glass of the frame is covered, save for a 3¼ × 3¼ opening in its centre, with black paper, and a piece of wood, also with a hole the size of a standard lantern plate, replaces the normal back. A little door is hinged to the opening, and is fitted with a turn-button or spring to keep it closed in use.

The negative is adjusted to the opening in the mask, the back put into place, and a lantern-plate dropped into the opening. It thus registers immediately and with certainty with the required part of the negative.

Types of Lantern Plate.—The transparencies are made on lantern plates, of which there are two types. One, similar to bromide paper and of about the same speed, gives pure black tones, while the other, requiring rather longer exposures, gives warm-toned images. The bromide plates are available in two contrast-grades in at least one make, and there are, of course, differences in contrast between plates of different make. In addition, a certain amount of contrast control can be had by varying the time of development. To keep the density constant, exposure naturally needs to be a little longer for short development than for long.

Exposure.—The correct exposure is found by trial and error, using test-strips cut from one of the plates by means of a diamond or wheel cutter. If the negatives to be printed are all of much the same contrast, it is often economical to establish the relationship between the exposure required for the slide and that needed to give a normal print on bromide paper. Exposures can then be determined by using test-strips cut from the paper.

Development.—With each brand of lantern-plate a formula for a developer is issued, and it is in general best, at least until familiarity with the material is gained, to use the maker's formula.

For pure black tones with bromide plates a plain hydroquinone developer is often used; a suitable formula is:—

Hydroquinone . . .	80 gr.	(9 gm.)
Sodium sulphite (anhydr.) .	220 gr.	(25 gm.)
Caustic soda	50 gr.	(5·5 gm.)
Potassium bromide . .	15 gr.	(1·7 gm.)
Water to	20 oz.	(1000 c.c.)

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Any ordinary metol hydroquinone or amidol developer as used for bromide paper will also be found suitable, but may give less contrast than the above hydroquinone developer.

Warm-tone Plates.—For warm-tone plates a standard M-Q developer, as for bromide paper, is suitable, and on most makes of plate will give a tone that is only slightly warm, but by using a warm-tone developer as recommended by the makers (usually containing either no metol or very little) warmer tones can be had, and still warmer images are given if the exposure is increased and the developer diluted. Loss of contrast when doing this can usually be combated by adding additional restrainer.

For the warmer tones a pyro developer has often been recommended. A suitable formula is :—

A.	Potass. metabisulphite .	35 gr.	(4 gm.)
	Pyro . . .	100 gr.	(12 gm.)
	Water to . . .	20 oz.	(1000 c.c.)
B.	Sodium carbonate (cryst.) .	880 gr.	(100 gm.)
	Sodium sulphite (cryst.) .	880 gr.	(100 gm.)
	Potassium bromide . .	20 gr.	(2 gm.)
	Water to . . .	20 oz.	(1000 c.c.)
C.	Ammonium carbonate .	880 gr.	(100 gm.)
	Ammonium bromide .	880 gr.	(100 gm.)
	Water to . . .	20 oz.	(1000 c.c.)

For a warm-black tone A and B are mixed in equal parts ; for warmer tones the exposure is increased and solution C is added to the developer. The following table gives typical relative exposures, developer formula, and time of development for different colours.

Tone.	*Exposure.*	*Developer.*	*Development Time.*
Warm black	1	A 8, B 8 parts	2½ min.
Sepia	1·5	A 8, B 8, C 1 part	4 min.
Brown	3	A 8, B 8, C 2 parts	10 min.
Purple-brown	6	A 8, B 8, C 4 parts	20 min.
Red	15	A 8, B 8, C 8 parts	25 min.

The C solution above can also be added to hydroquinone and most other developers (except amidol) and will give very similar results. It should be noted that the presence of metol

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or paraminophenol in a developer may make it difficult to obtain warm tones.

An acid amidol developer can also be used ; as development is in any case very slow, there is no need to dilute or otherwise alter it for various tones, which is often a convenience. It may be prepared according to the following formula, and must be used within a few hours.

Sodium sulphite (anhydr.) .	44 gr.	(5 gm.)
Amidol	22 gr.	(2·5 gm.)
Potass. metabisulphite .	175 gr.	(20 gm.)
Ammonium bromide . .	44 gr.	(5 gm.)
Water to	20 oz.	(1000 c.c.)

In aiming for tones warmer than those given by full development in an undiluted developer, haphazard work is particularly to be avoided, as with three variables—exposure, composition of developer, and development time—good slides are by no means easy to make unless the approach to the work is methodical. It is best to make up the developer to suit the tone required, and then experiment with exposure and development time until a suitable development time is found. Finding the correct exposure is then simple, and good slides of the desired colour can be made with certainty.

Three-Bath Development.—Since for almost any reasonable exposure that can be given to a warm-tone lantern plate there will be a developer-mixture that will be correct, tentative development can be adopted when the exact colour of the finished slide is not regarded as important. Three different developers—*e.g.*, those for red, brown, and black tones in the above table—are prepared, and the slide is given an exposure estimated to be more than the minimum, but not more than about ten times this.

It is then put into the most highly restrained developer. If the image does not appear in a reasonable time, exposure has not been enough for the " red " developer ; the slide is therefore rinsed and transferred to the less restrained " brown " developer. If even this fails to develop it satisfactorily, it is rinsed again and put into the unrestrained " black " developer. By this means the making of test-strips can be avoided, and a slide of normal density is assured. Its colour, however, is a matter of chance.

For a similar procedure, but using one developing bath only, the acid amidol formula given above may be adopted.

The Thiocarbamide Process.—Very beautiful slides with a blue image of very delicate tones can be made by using a

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developer containing thiocarbamide, a substance having a solvent action on silver bromide. The process has, however, a reputation for unreliability.

The following solutions are required :—

A.	Metol	44 gr.	(5 gm.)
	Sodium sulphite (anhydr.).	220 gr.	(25 gm.)
	Hydroquinone . .	22 gr.	(2·5 gm.)
	Sodium carbonate (anhydr.)	160 gr.	(18 gm.)
	Water to . . .	20 oz.	(1000 c.c.)
B.	Ammonium carbonate .	2 oz.	(100 gm.)
	Ammonium bromide .	2 oz.	(100 gm.)
	Water to . . .	20 oz.	(1000 c.c.)
C.	Thiocarbamide . .	66 gr.	(7·5 gm.)
	Ammonium bromide .	22 gr.	(2·5 gm.)
	Water to . . .	20 oz.	(1000 c.c.)

Lantern plates of the warm-tone type are in general the most satisfactory. The following table by Dr. Glover will show the relative exposures, composition of developer, and development times found suitable for different colours.

Colour.	*Exposure.*	*Developer.*			*Development Time at 70° F.*
		A	B	C	
Normal black	1	16	0	0	30 sec.
Neutral black	4	14	1	1	300 sec.
Blue-black	8	12	3	1	600 sec.
Blue	16	11	4	1	720 sec.
Violet-blue	32	10	5	1	800 sec.

Kodak Ltd. recommend 11 parts A, 4 parts B, and 3 parts C for their L5 lantern plates, giving a development time of 12 minutes.

Note that the process is decidedly sensitive to small changes in developer concentration and temperature of development. The latter should be kept strictly constant by means of a water-bath, and the quantities of solutions A, B and C, should be accurately measured. The colours tend to be distinctly unreliable even when all precautions are taken, and the final colour is not shown till the slide is dry. A good slide by this process is considered by many to be of finer quality than can be obtained in any other way.

The finished slide, whatever its colour, should have full gradation throughout, and though the shadows must certainly

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be strong they must on no account be blocked up. The best contrast for a slide depends to some extent on the conditions under which it will be shown ; a slide suited for projection in a large hall or with a powerful light would be too strong for home projection with a small lantern.

As slides may be exposed to considerable heat in the lantern, they should be hardened before drying. Any of the methods used for hardening negatives is suitable. Dust must be scrupulously avoided ; the magnification involved in projection makes most unpleasantly prominent any dust particles that may have stuck to the slide in drying. For the same reason, mechanical imperfections on the negative show much more than on a print, and spotting is so difficult as to be impracticable for any but the most skilful worker.

Printing by Reduction.—Where the size of the original negative, or the required part of it, is such as to make printing by contact unsuitable, the slide may be made by projection with an ordinary enlarger. If the negative is larger than the slide, reduction will be required, and for this it is essential that the enlarger should have a long extension. Where the enlarger is not capable of being extended far enough to project a reduced image when using its normal lens, it is necessary either to improvise some means of carrying the lens farther from the negative or else to replace the lens temporarily with one of shorter focal length. As a makeshift the focal length of the standard lens may be decreased by adding a positive supplementary lens, but if the alteration in focal length is large this is likely to necessitate extensive stopping down.

If a long-extension camera with a focusing screen is available, slides may be made by reduction in the camera. For this a lantern plate is loaded into the dark-slide as though it were a plate, the negative is set up at the window or in front of a suitable diffused artificial light, and is simply photographed on the slide. The process is practically identical with copying a print (see COPYING).

Printing by Enlargement.—Now that so many negatives are made with miniature and other small cameras, slides more often need to be made by enlargement than by reduction. The procedure in this case is exactly like that of making an enlarged bromide print. Where the degree of enlargement is small, focusing should be done on a spoiled lantern plate to which white paper has been pasted rather than on the baseboard, or the thickness of the plate may throw the focusing out enough to be noticeable. To prevent reflection the

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lantern plate should always be laid on black paper, never on the white focusing surface of the baseboard or easel.

Finishing the Slide.—Before it is ready to show in the projector, a slide has to be masked, bound and spotted. Ready-cut masks can be bought, but it is best to make each mask to suit the exact size of the picture-area required. Plain black gummed paper may be used, or there is available commercially an uncut mask ruled in small squares so as to enable an exactly rectangular opening of any size to be cut without difficulty.

Over the masked slide is laid a cover-glass, which may be purchased as such or made by dissolving the gelatine off a spoiled lantern plate. The two are bound together round the edges by strips of black gummed paper. "Spotting" the slide consists in affixing a small disc of white paper to guide the projectionist in inserting the slide into the carrier; holding the slide so that it is seen as it is to appear on the screen, the spot goes at the bottom left-hand corner facing the observer. Many existing British slides have two spots at the two top corners; this method of spotting, however, is now obsolete.

For Continental standard slides, a single white spot at the lower right-hand corner is used, while in the U.S.A. one white spot at the lower left-hand corner is again standard. This may be replaced by a red strip along the bottom edge.

Miniature Transparencies.

Transparencies in the 24 × 36 mm. size can be made either on lantern plates or on lengths of positive 35-mm. cine film. In either case it is usual to print by contact from miniature negatives.

Lantern plates of size 5 × 5 cm. can be obtained from any maker, and are used exactly as are the plates of larger size already discussed. For this size, however, special lantern-slide printers can be obtained; with one of these the work is very considerably expedited and the risk of scratching negatives or slides is reduced to a minimum. So far as results are concerned, a printing frame made up on the lines suggested under *Printing by Contact* above, but fitted to take the negative film in whatever lengths are convenient for the individual user, will be found equally effective. The slides are masked and bound exactly as are their larger counterparts.

Owing to the low price at which 35-mm. positive film may be bought, many workers prefer this material to the small lantern plates. It has approximately the characteristics of a fast black-tone plate, and gives transparencies of perfect quality.

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Printing is done on strips about 2½ in. long, using an ordinary printing frame, and the exposed film is developed, fixed, and hardened exactly like a slide. After drying, it is cut as required and bound up between glasses.

Film transparencies are frequently made in continuous lengths intended to be fed through the projector from one spool to another. Two long lengths of cine film—one of negatives, one the positive stock—are not easy to handle simultaneously, particularly as the only part of the positive film that may be exposed to light is the one frame being printed. One of the special printers devised for the work is therefore much to be preferred to any printing frame. Such a printer allows the positive film to be fed, frame by frame, past a mask against which are also placed, in turn, the negatives to be printed. After exposure, the entire strip of transparencies, printed, it may be, from negatives on many different rolls, is developed as a unit in an ordinary tank. (See DEVELOPMENT.) Though not so durable as glass slides, a film-strip of this sort is inexpensive to make and convenient to exhibit, and has the advantage than the lanternist cannot mistake the order of showing. (See also FILMSTRIP.)

Where a miniature camera is used for colour work in con-function with a larger camera for monochrome photography, a miniature projector is usually also acquired for showing the colour transparencies. Sooner or later the user of such a combination will desire to show his monochrome pictures by projection, which he can only do by making miniature slides or filmstrips by reduction from his larger negatives. Except in detail, the procedure involved is exactly that of making standard sizes by reduction from larger negatives. (See *Printing by Reduction* above.) Where a film-strip is to be made through the enlarger, means must be devised for rolling the film, behind a mask, from one spool to another, the holder being so made that it can lie on the baseboard. The camera body, with lens removed, can often be used as a film-holder, the picture being projected through the open lens-flange. The focal-plane shutter of the camera is then used for exposing. A dummy focusing surface must be provided of the same thickness as the film-holder. Similar schemes will suggest themselves in connection with the other methods of printing by reduction described in the section referred to.

For INTENSIFICATION, REDUCTION (IN SIZE) or TONING, see under these respective headings.

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Latensification. A term coined to imply intensification of the latent image, and applied to hypersensitising, after exposure, by slightly fogging the film by prolonged exposure to a very faint light or by exposure to the vapour of mercury or to sulphur dioxide. See HYPERSENSITISING.

Latent Image. See IMAGE, LATENT.

Latitude. Ability of a film to accept without serious loss of image quality an exposure longer or shorter than the ideal exposure. See SENSITOMETRY.

Law of Inverse Squares. See INVERSE SQUARES, LAW OF.

Lead Intensifier. See INTENSIFICATION.

Lead Nitrate (Fr., *Azotate de plomb ;* Ital., *Azotato di piombo ;* Ger., *Bleinitrat*). $Pb(NO_3)_2 = 331$. Synonym : Plumbic Nitrate. Made by dissolving litharge or white lead in nitric acid, evaporating and crystallizing. It occurs in hard, white, opaque, octahedral crystals. It is used in intensification (*q.v.*) and has been used as a constituent of some combined toning and fixing baths. (See below, and TONING.)

Like all lead salts, it is poisonous, and as lead is a cumulative poison, very special care should be taken by those who use it frequently.

Leather, to Revive. As leather enters so largely in the coverings, etc., of cameras, the following hints for its treatment will be useful : *Cleaning leather*—Saddlers' soap, obtainable from any working saddler. *For leather that has become very dry, etc.*, the best treatment is gentle rubbing with sweet oil, or preferably castor oil, once a day for a week or so. This treatment tends to prevent cracking, and is good for leather carrying-cases, straps, etc. *Darkening leather*—Nigrosin may be mixed with thin shellac varnish ; or the white of an egg beaten up with 5 to 10 drops of strong ammonia, and mixed with nigrosin or Indian ink ; or take 10 parts of shellac, 100 parts of alcohol, and 1 part of nigrosin. For *renovating leather* use ordinary furniture polish or an ounce (30 c.c.) of turpentine, in which is dissolved a bit of beeswax about the size of a marble, plus about a teaspoonful of linseed oil. A *leather varnish* can be made with methylated spirit saturated with shellac, or methylated spirit, 100 parts ; shellac, 12 parts ; white turpentine, 6 parts ; gum sandarac, 2 parts ; gas black, ½ part ; spirit of turpentine, 6 parts. Bookbinders' leather

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varnish or French leather varnish can also be used. There are several excellent leather revivers on the market ready prepared for use. (See also BELLOWS and BLACKING. To mend *leather bellows*, etc., see MARINE GLUE.)

Lens (Latin, *lens*, a small bean or lentil). A lens is a piece of transparent material (usually glass) bounded by curved surfaces (generally spherical, including flat). Transparent substances have the property of bending, or refracting, rays of light which fall obliquely, and the effect of the curvature of the surface is to cause all rays emanating from the point to be refracted so as to pass through a second point. The first is called the object point and the second the image point.

Any extended object can be regarded as an assemblage of points, to each of which corresponds an image point, the whole assemblage of image points forming the image of the object. When light, diverging from the object point, is caused by the lens to converge to the image point, the lens is called convergent (or collective); it will be found to be thicker at the centre than at the edges.

There are also lenses which are thicker at the edges than at the centre, and these are called divergent (or dispersive), because they cause light diverging from a point to diverge still more; hence no image is formed, but the point from which the rays diverge after passing through the lens is still considered the image and is then said to be virtual. The image formed by a convergent lens may also be virtual if the divergence of the rays is too great to be overcome by the convergence of the lens; where, however, an image can be received on a screen that image is said to be real.

A convex or bulging curvature of the lens surface produces convergence, a hollow or concave surface produces divergence, so that a convergent lens must have at least one surface convex, and according as the other is convex, flat (plane), or concave the lens is called double convex, plano-convex, or meniscus. Similarly divergent lenses may be double concave, plano-concave, or meniscus. These forms are illustrated in Fig. 1. The line joining the centres of the spheres of which the surfaces of the lens are part is called the axis of the lens.

The History of Photographic Lenses.

It would appear that lenses of at least a primitive kind have been known from very remote antiquity, and Aristophanes (about 430 B.C.) writes of the transparent crystal (λίθος διαφανής)

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then used as a burning-glass to light fires. Whether this was of glass or of natural crystal is a matter of conjecture. Spectacle lenses are mentioned by Giordano da Rivalto in 1305, as having been invented only "twenty years ago." This will fix the date at 1285, when they were constructed by Salvino d'Armati, a Florentine. Alessandro della Spina, having seen some of Armati's spectacles, made them for himself, and published the method of manufacture. The manufacture was long almost confined to Italy. Sir Christopher Wren was one of the first to make satisfactory lenses in Britain. In past times all lenses were made of crown or flint glass, the former being free

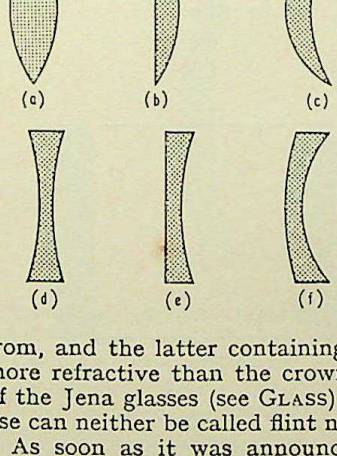

FIG 1. (a) double-convex; (b) plano-convex; (c) concavo-convex or converging meniscus; (d) double-concave; (e) plano-concave; (f) negative concavo-convex, sometimes called convexo-concave or divergent meniscus.

from, and the latter containing, lead, the flint being slightly more refractive than the crown; but since the introduction of the Jena glasses (see GLASS) many of the optical glasses in use can neither be called flint nor crown.

As soon as it was announced in 1839 by Daguerre and Fox Talbot that they had been enabled to obtain a permanent image in the camera obscura, the ability and skill of mathematicians and opticians were brought into play to produce lenses which should be free from the objections common to the double-convex lens, which was that generally used in the camera obscura in those days. The single lens was replaced by the achromatic combination of the telescope (Fig. 2). This was eventually reversed, and the plane side presented to the object, as in Fig 3. Then Wollaston's meniscus (Fig. 4) came to be recognised as a means of extending the definition; and in 1840, Chevalier, a Paris optician, still

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further improved it by a different method of achromatising the lens. But in 1841, through the agency of Voigtländer, a practical optician, a lens designed by Professor Petzval, a mathematician of Vienna, was made and introduced commercially. This was the portrait lens ; and it is a remarkable fact that it is the model for many portrait lenses of the present day. Fig. 5 is a sketch of Petzval's original portrait lens :

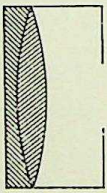

FIG 2.

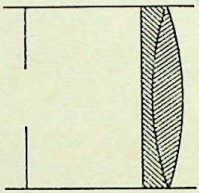

FIG. 3.

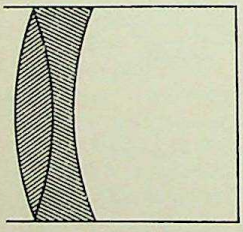

FIG. 4.

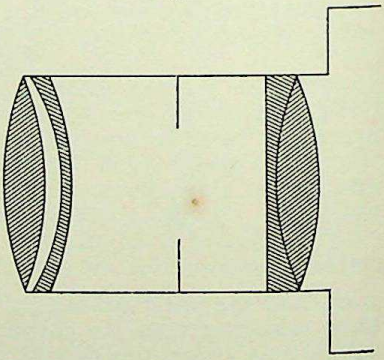

FIG. 5.

the coarsely shaded parts are crown, the finely shaded parts are flint glass. This has been modified by Dallmeyer, by Grubb, and the noted American optician Morrison : but all are constructed on the principle of the same lens. Professor Petzval calculated at the same time a landscape lens which was not introduced commercially till 1857 ; and an English optician, in 1858, having suggested a lens with a concave glass in place of the diaphragm to lengthen the focus and flatten the field, Dallmeyer introduced his famous triplet which was much used and admired.

Single lenses were first of all of the kind shown in Fig. 3, with which extremely small diaphragms are necessary to reduce

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spherical aberration. This was improved on by Slater, Grubb, and Steinheil, and eventually took the form shown in Fig. 6. A crown-glass lens of meniscus form is presented to the object, and is cemented to a flint meniscus. This gives a much flatter field, and allows the use of larger diaphragms.

The rapid rectilinear doublet, or R.R. lens, consists of two of the aplanatic single lenses (Slater-Grubb-Steinheil form, Fig. 6), mounted in a tube with a diaphragm between. If really good this form will well cover a plate the longer dimension of which is two-thirds the focal length of the lens, and quite good definition will be obtained with an aperture of *f*/8. Thus a good rectilinear doublet of about 6 in. focal length will well cover a quarter plate ($4\frac{1}{4}$ by $3\frac{1}{4}$) at an aperture of *f*/8. In all doublets, the diaphragm is placed between the combinations,

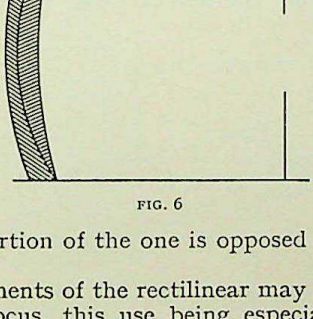

FIG. 6

so that the distortion of the one is opposed by the distortion of the other.

The single elements of the rectilinear may be used as simple lenses of long focus, this use being especially desirable for landscapes, or pictorial effects in portraiture.

The front lens, with stop behind, gives excellent central definition. By stopping down, the fine definition extends all over the field. The back lens, with the stop in front, gives rather soft definition at full aperture ; but the definition is even all over the field, and can be sharpened by stopping down.

Nodes and Nodal Planes.

If a convergent lens is held up to the sun or other distant object, the distance of the image from the lens is called the focal length. Most photographic lenses consist of several constituents, so that there is no definite point for measurement ; in this case the focal length is defined as the focal

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length of that single thin lens which will produce an image of a distant object the same size as that formed by the given lens.

If we measure from the focus towards the lens a distance equal to the focal length, we arrive at a point called the nodal point. Another nodal point can be found by turning the lens round end for end.

The two nodal points and the focal length completely define the lens and enable us to find the image of any object by means of another property. Any ray through one nodal point will emerge from the lens as if it came from the other nodal point unchanged in direction ; moreover any ray meeting the plane through a nodal point, perpendicular to the axis, called the nodal plane, emerges as if coming from a point on the other nodal plane at an equal distance from the axis.

Thus in Fig. 7 let the nodal planes be RQ and R′Q′, and the focal length f = B′F′. A ray from a distant point on the axis will be parallel to the axis. Let PQ be such a ray ; it will be refracted by the lens to pass through the focus F′ ;

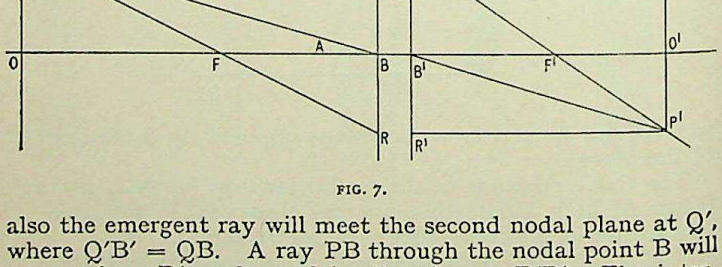

FIG. 7.

also the emergent ray will meet the second nodal plane at Q′, where Q′B′ = QB. A ray PB through the nodal point B will emerge from B′ unchanged in direction as B′P′. The intersection of these two emergent rays determines the image of P viz. P′. O′P′ is the image of OP. If we call OB, u and O′B′, v, the formula connecting u and v, which are called conjugate distances, is

$$1/u + 1/v = 1/f.$$

Furthermore we have the ratio

$$\frac{\text{size of image O′P′}}{\text{size of object OP}} = \frac{v}{u} = \text{magnification.}$$

also OB or $u = (1+1/m)f$ and $v = (m+1)f$.

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It can be verified that these values fit in with our formula above. OF is thus seen to be f/m and $F'O' = fm$, so that $OF.\ F'O' = f^2$.

Aberrations.

The rules given above for finding the image apply only to a perfect lens, or where the diameter of the lens and of the object are small compared with the focal length. In practice good photographic lenses are as nearly perfect as possible for a given specified range of aperture and image size, and this is brought about by the skilful combination of components by the lens designer, whereby the errors of one component are cancelled by opposite errors in another.

The errors which may be present in lens images are classified under five aberrations which depend on the shape and focal lengths of the lenses producing it, and two chromatic aberrations which arise from the unequal refraction of glass for

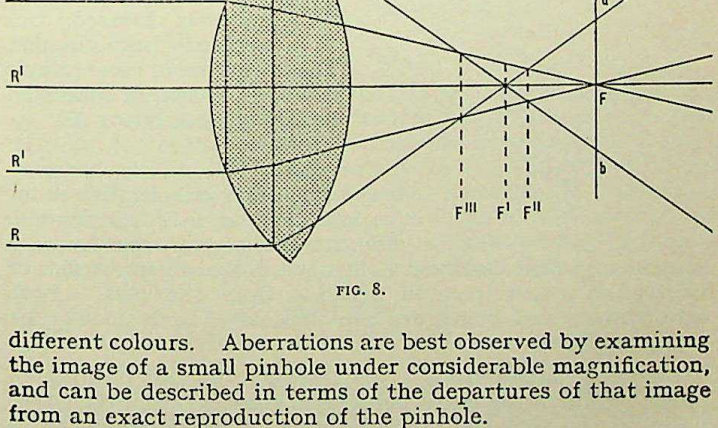

FIG. 8.

different colours. Aberrations are best observed by examining the image of a small pinhole under considerable magnification, and can be described in terms of the departures of that image from an exact reproduction of the pinhole.

Spherical aberration is seen in the images of axial points and arises from the inability of the lens to refract the rays falling on the marginal and central portions of the lens to the same point. This defect is illustrated in Fig. 8. It is impossible to get a sharp focus where this aberration is present, but improvement

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can be obtained by stopping down (reducing the aperture). The image of the pinhole will be round but unsharp.

Coma is a similar defect appearing in points away from the axis, but owing to the unsymmetrical refraction for oblique rays the image of a round hole is no longer round but shaped rather like a top. The image can again be improved by stopping down.

Astigmatism is shown by an inability to bring horizontal and vertical lines to focus in the same plane at the top and bottom, or sides, of the field. At the focus for horizontal lines, the image of a point is drawn out to a very narrow ellipse (practically a line) lying horizontally ; at the focus for vertical lines, the image is similar, but lies vertically. At an adjustment of focus between the two, the image of a point is blurred, but approximately circular. The formation of these images is clearly shown in simplified form in the diagram Fig. 9.

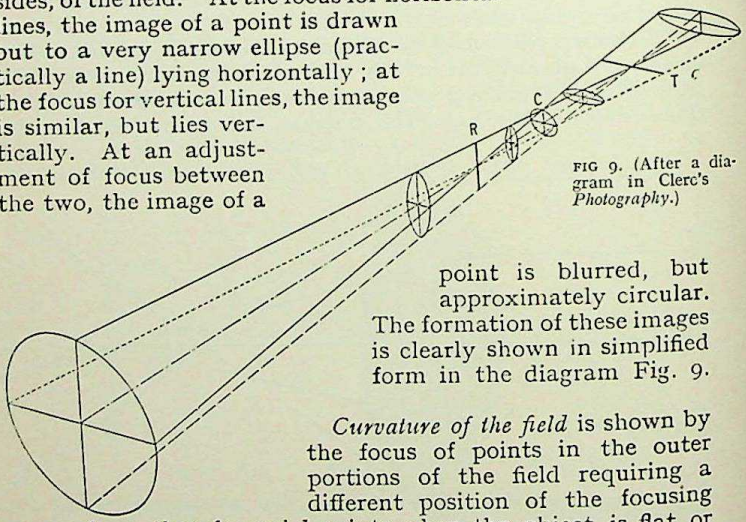

FIG 9. (After a diagram in Clerc's *Photography*.)

Curvature of the field is shown by the focus of points in the outer portions of the field requiring a different position of the focusing screen from that for axial points when the object is flat or wholly at a considerable distance from the lens. Both astigmatism and curvature are diminished only slowly by stopping down.

Distortion arises from a displacement in the position of image points in the outer portions of the field from their true positions, so that the image is not a true representation of the object, *e.g.*, the image of a rectangular window-frame will have its sides curved. If the sides are concave the distortion is called pincushion, if the sides are convex the distortion is barrel.

If the focusing screen or the photographic surface is not

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parallel to the window frame the sides of the image will converge ; this is called " keystone distortion " and is not a defect of the lens, but is due to incorrect usage.

Chromatic aberration is a fault which results in the focus for, say, blue light being different from that for yellow light, as suggested in Fig. 10. Now white light consists of a number of coloured constituents, red, orange, yellow, green, blue and violet, and if there is a different focus for each colour the image cannot be correctly focused anywhere, but will show coloured fringes ; this is called axial chromatic aberration.

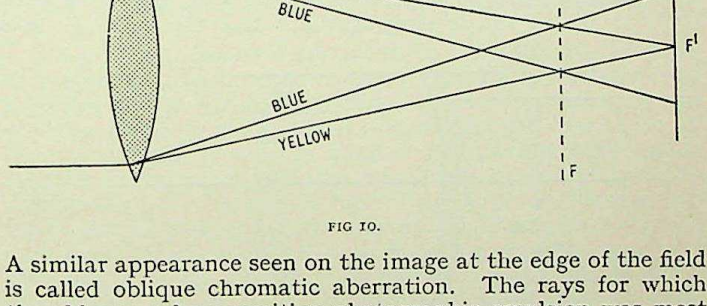

FIG 10.

A similar appearance seen on the image at the edge of the field is called oblique chromatic aberration. The rays for which the old non-colour-sensitive photographic emulsion was most sensitive are invisible and lie beyond the violet end of the visible spectrum. With such an emulsion it sometimes happened that when one object was focused on the screen the photograph showed sharpest focus on another (nearer) object ; the lens was then said to have " chemical " focus.

Field of a Lens.

If a lens is placed on a camera much larger than it is intended for and focused on an open scene, it will be seen that only a circular portion of the focusing screen is illuminated ; the diameter of this circle is the field of the lens. It will also be noticed that the image is indistinct towards the margin and that only the image within a circle of diameter D is sharply defined ; then D is called the useful field or the circle of good definition. Finally, if d is the diagonal of the plate for which the lens is listed, d is the camera field. Obviously D should be greater than d. Field is usually expressed as an angle

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subtended at the nodal plane (say A). Then A is found from the formula $2 \tan A/2 = d/f$.

Aperture.

Suppose the lens focused for a distant object. The largest circle of light that is utilised by the lens in forming the image is called the aperture. This need not correspond with the diameter of the lens, as may be seen from Fig. 11, which shows the section of an imaginary lens. A beam of light whose diameter is AA′ is converged by the first lens, and passes through the stop or diaphragm BB′ to the second lens, which converges it to the focus F. It will be seen that it is the opening BB, not the rims of the lenses, that limits the diameter of the beam; AA′ is the aperture d of the lens. The ratio $d : f$ is

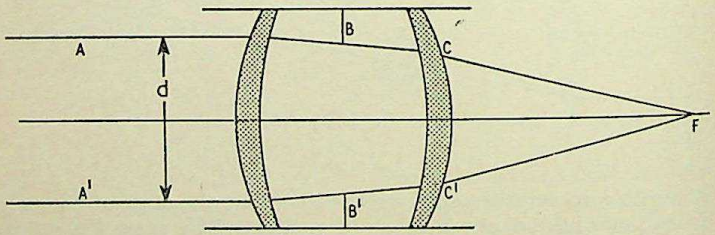

FIG. 11.

called the f/number, usually denoted by N. Thus an $f/5$ lens is one in which the largest beam of light that can get through is one-fifth the focal length. The exposure that must be given is proportional to N^2, so that an $f/4$ lens requires four times the exposure of an $f/2$ lens. (See also DIAPHRAGMS.)

Types of Photographic Lenses.

The requirements of a photographic lens are that it should form a sufficiently good image of large angular extent and that the aperture ratio should be not too small. It is found that satisfactory snapshots can be taken in $\frac{1}{40}$ sec.. which suits the simple shutters on the inexpensive cameras, and a sufficient exposure can be obtained in bright light, with modern emulsions, with a lens having an aperture of $f/14$. This then may be looked on as the minimum aperture that should be expected

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in a photographic lens intended for general purposes including snapshotting.

A satisfactory single non-cemented lens can be made having this aperture, covering a field of about 50° (that is, the focal length is about equal to the diagonal of the plate). The lens is a meniscus (fig. 1c) placed either in front of or behind the diaphragm, the position of which is important. The lens is not corrected for spherical aberration, chromatic aberration, or coma, but these are unimportant at this aperture; more serious is the distortion, and this can be cured by employing two menisci, one before and one behind the stop; this is the periscopic lens, and can have an aperture of about *f*/11. To increase the aperture it is necessary to correct the spherical and chromatic aberrations, which requires each lens to be compound; this gives the rapid rectilinear, having an aperture of *f*/8.

None of these lenses is corrected for curvature of the field, correction of which requires special glasses which were not available to the earlier opticians. The incorporation of this special material in the rapid rectilinear brought the number of components up to six. A number of different anastigmats (as they are called) of this type were made having an aperture usually of *f*/6·8. The advantage of this type, comprising two members of equal or slightly different focal lengths, was that additional lenses having longer focus (at smaller aperture) were available by use of either the front or the rear member separately; these lenses were therefore known as convertible. In striving to improve the definition or increase the aperture, opticians added other components till each member contained four or even five lenses cemented together, and manufacture became difficult.

The English optician, H. D. Taylor, on the other hand found that by using separated lenses he could achieve equally good results with three glasses only. This was the Cooke lens; it is not convertible but lends itself readily to the design of lenses of large aperture, up to *f*/3, so that many modern high-speed lenses have developed from the Cooke. Indeed, the great majority of lenses used at the present time by the more or less advanced amateur are three-glass lenses based on the Cooke design, and modern glasses have enabled the performance of the lens to be greatly enhanced, or its aperture widened, or both. For miniature cameras, three-glass lenses of maximum aperture *f*/2·8 are widely used, and the best of them perform extremely well. In more expensive instruments, however,

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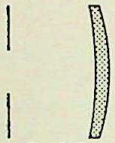
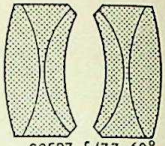
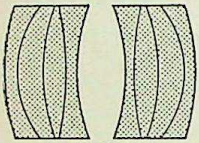


MENISCUS
f/14, 45°

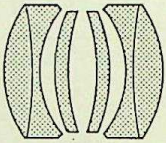
R.R. f/8, 45°



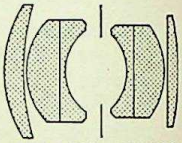
GOERZ f/7·7, 60°



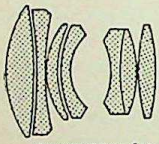
ZEISS PROTAR
f/6·8, 55°



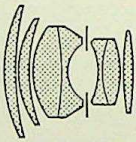
ROSS W.A.
f/4, 65°



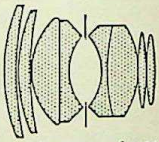
T.T.H. SPEED PANCHRO
f/2



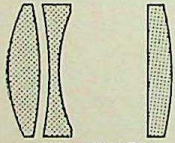
SUMMICRON f/2



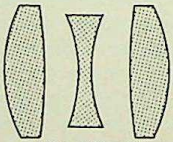
CANON f/1·2



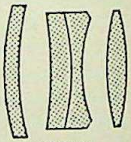
ANGENIEUX f/0·95
(16 MM CINE)



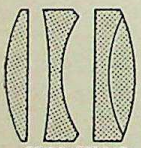
T.T.H. COOKE
f/6·5, 46°



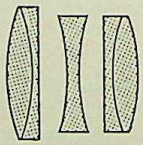
T.T.H. f/3, 40°



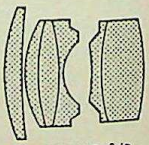
HEKTOR
(PROJECTION)



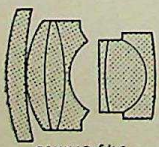
ZEISS TESSAR
f/3·5, 50°



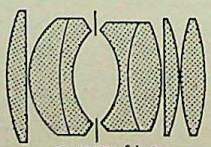
DALLMEYER
PENTAC
f/2·9, 45°



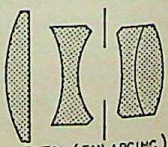
SONNAR f/2
QUINOR f/2
NIKKOR f/2



SONNAR f/1·5
NIKKOR f/1·4



FUJINON f/1·2



ENTAL (ENLARGING)
f/4·5

FIG. 12.

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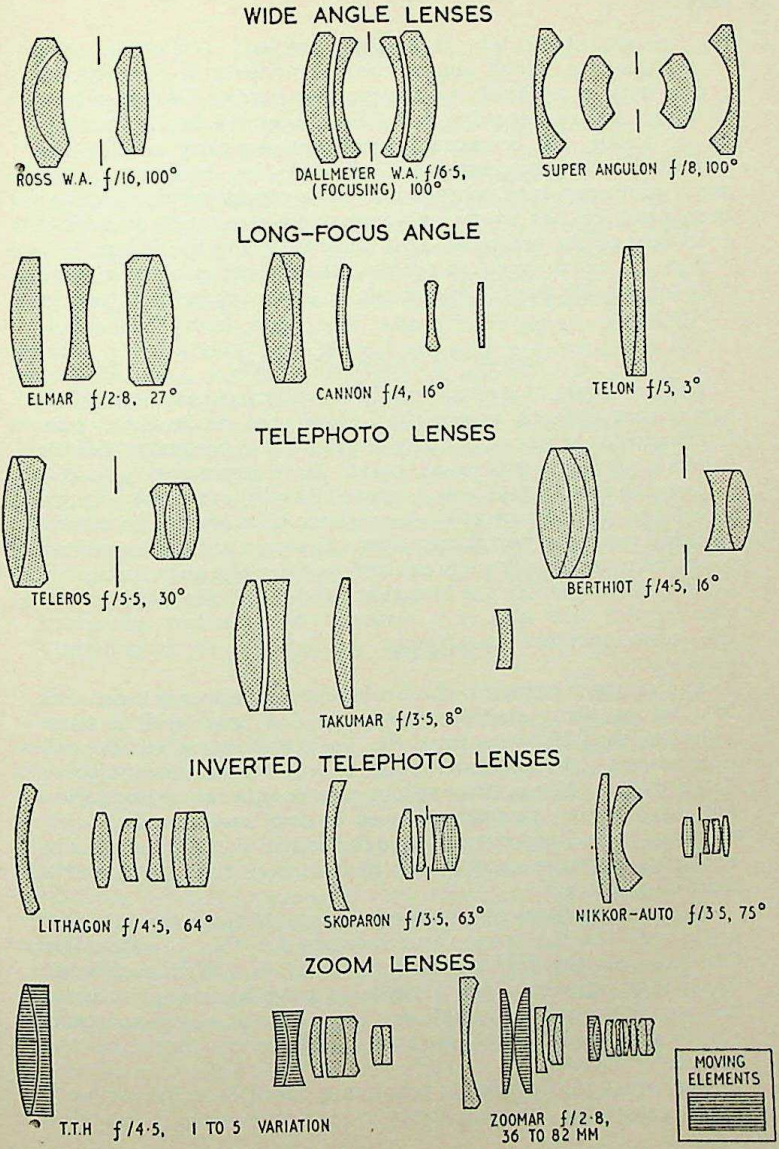

FIG. 13.

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the lenses are often four-glass pattern, following the Zeiss Tessar in which one of the components of the original Cooke lens is replaced by a cemented pair. The maximum aperture seldom exceeds *f*/2·8. For faster lenses, of aperture *f*/2 or wider, six or more glasses are generally used. The introduction of blooming has allowed the designer to use many more separate components than would previously have been practical, as every unbloomed air-glass surface adds a good deal to the scattered light accompanying the image.

Figs. 12 and 13 give, in section, the construction of a large number of lenses of historical interest, or which are in current use.

Lenses for Special Purposes.

Various types of lens are made for different purposes. For portraiture indoors, where the light is not more than one-hundredth as bright as outdoor daylight, it is necessary to have a lens of large aperture to make short exposures possible. Before the anastigmat was invented the Petzval lens (fig. 5), which had an aperture of *f*/3·5, was generally used. To obtain pleasing results in portraiture a lens having a rather long focus in relation to its plate is required, so that the angular field is small; consequently the fact that the field of the Petzval lens was curved was not very serious. Nevertheless nowadays the large aperture anastigmat of Cooke type is generally preferred.

At the other extreme, the professional whose work consists in photographing stationary objects does not need a large aperture, but his lens must be very well corrected for all aberrations. An aperture of *f*/6 to *f*/8, with a field of 50 to 60° is usual. For photographing documents for reproduction and for copying paintings lenses having special colour corrections, called process and apochromatic process lenses, are used; these have an aperture of not more than *f*/10, and a field of about 45°.

The architectural expert often has to photograph interiors with very limited space, and requires for this a wide-angle lens in which the field reaches 100° or more. With such large fields it is unreasonable to expect a large aperture; usually the working aperture is *f*/16, but sometimes a larger aperture, *f*/6, is provided to yield an image sufficiently bright on the screen for focusing.

The press photographer requires a rapid lens having very good corrections, since he must get his results often in very dull

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weather; the press lens has a field of about 50° to 55° and an aperture of $f/4{\cdot}5$ or wider. For interior work he requires a still more rapid lens, but as such a lens and its camera would be bulky he uses a miniature camera in these circumstances. The small size makes it inconspicuous, and the small lens has considerable depth of focus even at large apertures. In the small sizes the optician can increase the angle of field, which enables him to reduce the focal length of the lens for a given size of negative, and this leads to still further reduction in bulk. These lenses can cover 55° at an aperture of $f/2$, or even $f/1{\cdot}5$, and the negatives will stand considerable enlargement.

A special type of lens is the telephoto, originally made by placing a dispersive lens behind an ordinary photographic lens to increase the focal length. Its special virtue is that the camera extension is very much less than with a normal lens of the same focal length. Originally the separation was made variable so that the focal length could be altered, but it was impossible to make this arrangement well corrected in all positions, and the aperture was very small. The modern telephoto is of fixed focal length and so can be used just like an ordinary lens. The aperture compares with that of normal lenses but the angular field is, of course, only half. For further details, see TELEPHOTO LENS.

Examination of Lenses.

The most effective test of the practical performance, in the matter of definition, is that made by photographing lens-testing charts under controlled conditions; this incidentally shows up any errors there may be in the optical adjustment of the camera. Suitable charts, with a manual describing methods of test, can be had from the Bureau of Standards, Washington, D.C., U.S.A. With the aid of these charts the resolution at all parts of the field can be evaluated in lines per millimetre, and the presence, and effect, of such faults as astigmatism and curvature of field can be determined with exactitude.

An old lens should be examined for scratches, chipped edges and deterioration of cement. This can be done by holding it up to a strong light having a dark border, *e.g.*, a window frame. By carrying the image of the dark border across the lens any defect will show up.

If a lens of old pattern and unknown quality is purchased, it may be desirable to put it through a more comprehensive

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series of tests to determine its performance. The following tests may be found useful.

1. *Equivalent Focal Length.*—Methods for determining this are given under FOCAL LENGTH (*q.v.*).

2. *Rapidity.*—A method of measuring the effective aperture of the various stops is given under DIAPHRAGMS (*q.v.*).

3. *Covering Power.*—A test for this is sufficiently fully indicated under " Field of a Lens " above.

4. *Spherical Aberration.*—If this fault is present, the image on the focusing screen of a small light source, sharply focused, will be seen to be surrounded by a halo of light. If no halo is found, spherical aberration is absent. But the presence of the halo is not definite proof of spherical aberration, as flare may produce a similar effect. A further check may be made by affixing to the lens a disc of black paper of diameter about three-quarters of that of the front component of the lens, and focusing a small bright object at full aperture. If, on removing the paper and stopping down the lens, the image requires re-focusing to obtain maximum sharpness, spherical aberration is definitely present.

5. *Chromatic Aberration.*—For a rough-and-ready test that will show up any really serious aberration, set up a series of objects at slightly different distances from the camera and focus the centre object sharply on the screen. Then take a photograph on a non-colour sensitive plate, and if any of the other objects are sharper than the centre one, chromatic aberration is present. (It is assumed that focusing screen and plate are precisely in register.) Since the photograph was effectively taken by blue light, by which alone a non-colour sensitive emulsion is affected, while focusing was done chiefly by the yellow light to which the eye is most sensitive, this test will show up any non-coincidence of the foci for these two colours.

A more stringent test is to photograph a sheet of small type first with a non-colour-sensitive plate (*i.e.*, by blue light only) and then with a panchromatic plate with a normal yellow or yellow-green filter. If the latter photograph is as sharp as the former, the lens may be regarded as free from any degree of chromatic aberration that would impair its performance for even the most exacting practical work. Further checks along these lines will seldom be needed ; if they are, much information can be obtained by photographing a carefully-focused object a number of times in succession, each photograph being taken through a different monochromatic filter.

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6. *Flare and Ghosts.*—To test for flare a large box (at least 2 ft. cube) is painted black inside. This is supported against the sky and a photograph taken with the black box in the centre of the picture and the sky showing on at least three sides. On development the negative should show practically clear gelatin where the image of the box comes; but if there is bad flare this image will be fogged; the amount of fog is a measure of the flare. Care should be taken not to confuse development fog with flare; compare the image of the box with the margins that were covered in the camera.

The procedure above will indicate any general fogging that may be expected from flare, but will not indicate the likelihood of a definite flare-spot or ghost image making its appearance if a brilliant point of light is included in the picture. Any failing of this sort may be detected by focusing a bright point of light against a dark background. With the image in the centre of the screen, a halo round the light may be seen; if so, slew the camera round to move the image to one side of the screen, and watch the halo. If it remains central, it may be assumed due to flare of the general or diffused type, but if it moves with the main image, it is due to a secondary image or " ghost " that is very much out of focus. (At some extension of the camera quite different from that needed to focus the main image, it may be found to be sharp ; the main image will now appear as a brilliant halo.) If, on slewing the camera round, main image and halo move in *opposite* directions, a particularly troublesome form of ghost or flare-spot is present, since it no longer surrounds the main image, but may appear in an unlighted part of the subject ; a flare-spot on the opposite side of the picture to the main light will always be very obvious when conditions are such as to lead to its appearance.

7. *Accuracy of Centring.*—This can best be tested for by looking through the lens at a small naked flame, of which several images will be seen if the lens is not directed straight at it. Rotate the lens about its axis—for example, by unscrewing it in its flange—and if the images do not remain stationary one or more of the glasses is inaccurately centred. Faulty centring may easily arise in an old lens that has been roughly handled, or has been remounted.

8. *Perfection of Polish.*—Look through the lens at a dead-black surface—*e.g.*, a piece of black velvet in shadow—with a strong side-light falling on the lens itself. If perfectly polished,

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the lens should appear completely black. A less perfectly polished lens will appear a more or less bright grey; this is due to light scattered at imperfectly polished surfaces.

Care of Lenses.

If the lens is detachable from the camera it should be removed when not in use and wrapped up to protect it from dust and other atmospheric contamination, and from the action of light. A folding camera should be kept folded up. Any dust should be removed from the surfaces of the lens with a fine dry camel's-hair brush. If it requires further cleaning a clean handkerchief should be used and moisture applied by breathing; if this fails to remove the dirt the handkerchief can be moistened with a little methylated spirits. Nothing further should be done. The inner surfaces rarely need attention, but if they do the components should be unscrewed one at a time, and each replaced before the next is dealt with, to ensure that the order of the lenses be not altered.

(See also BALSAMING, FOCAL LENGTH, FOCUSING SCALE, HYPERFOCAL DISTANCE, DEPTH OF FOCUS, PINHOLE PHOTOGRAPHY, LIGHT, SPECTACLE LENS, SUPPLEMENTARY LENS, CONJUGATE FOCI, etc.)

For a further study of lenses, refer to *Photographic Optics* by Arthur Cox (Focal Press.)

Lens Formulæ. (See also FOCAL LENGTH, FOCUSING SCALE, CONJUGATE FOCI, SUPPLEMENTARY LENS, ENLARGING, HYPERFOCAL DISTANCE, DEPTH OF FOCUS, TELEPHOTO LENS.)

The formulæ given below almost all appear elsewhere under various headings; they are collected here for convenience. Where a formula is more extensively discussed elsewhere, a reference is given to the appropriate article. For the interpretation of formulæ in general, see ALGEBRA.

The main symbols used are as follows; others are defined in connection with the formulæ in which they appear.

f = focal length
u = distance of object from node of admission of lens
v = distance of image from node of emission of lens
H = hyperfocal distance
m = magnification, or ratio of size of image to size of object

$= \frac{1}{r}$

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r = reduction, or ratio of size of object to size of image

$= \frac{1}{m}$

n = f-number of stop

c = diameter of circle of confusion

The fundamental formula of the lens, from which most others are derived, relates u, v, and . It is : $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

Alternative forms are :—

$$f = \frac{uv}{u + v}$$

$$u = \frac{vf}{v - f}$$

$$v = \frac{uf}{u - f}$$

Magnification $m = \frac{v}{u}$

Reduction $r = \frac{u}{v}$

In terms of m and r,

$$u = \frac{(m + 1)f}{m} = (r + 1)f$$

$$v = (m + 1)f = \frac{(r + 1)f}{r}$$

(See CONJUGATE FOCI, MAGNIFICATION and ENLARGING.)

If D is the effective diameter of a lens, then the f-number is given by $n = f/D$

or $D = f/n$ (See DIAPHRAGMS.)

To focus an object at distance u, the lens has to be moved forward, from the " Infinity " point, through a distance d given by $d = f^2 \div (u - f)$

Note that $d(u - f) = f^2$, and so is the same for all distances. The maximum permissible error, δ, in lens-to-film distance, at the Infinity setting, is given by :

$\delta = nc$ (See FOCUSING SCALE.)

When focusing with an extension-tube of length l,

$l = f/r = fm$

$u = (r + 1)f = \frac{f^2}{l} + f$

$r = f/l$ (See EXTENSION TUBES.)

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Lens Formulæ

When focusing with a positive supplementary lens of focal length S, then with the camera focusing set to " Infinity," $u = S$

With the focusing scale of the camera set to a distance D,

$$u = \frac{SD}{S + D} \text{ and } D = \frac{uS}{S - u}$$

In all these cases u is measured from the supplementary lens. (See SUPPLEMENTARY LENS, also DIOPTRE.)

When a supplementary lens of focal length S is added to the camera lens, the combination has a focal length F given by :

$$F = \frac{Sf}{S + f}$$ where f is the focal length of the camera lens.

If the supplementary lens is negative (diverging), prefix a minus sign to S in the above formula, or use

$$F = \frac{Sf}{S - f}$$, in which S is counted as positive.

The above two formulæ are exact only if the nodal separation a between camera lens and supplementary is negligibly small ; if it is not, the formulæ become :

$$F = \frac{Sf}{S + f - a}$$, or, for a negative supplementary,

$$F = \frac{Sf}{S - f + a}$$

To find the value of S needed to give a predetermined value of F

$$S = \frac{fF}{f - F}$$

If F is smaller than f, S will be positive, indicating a positive (magnifying) lens ; if F is greater than f, S will be negative, and a negative (diverging) supplementary will be required.

Taking the nodal separation a into account, the above formula becomes :

$$S = \frac{F(f - a)}{f - F}$$ (See SUPPLEMENTARY LENS.)

The hyperfocal distance H is given, *in all cases*, by

$$H = f^2/nc$$

If c can be taken as $f/1000$, this becomes :

$$H = \frac{1000f}{n}$$

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If it is preferred to relate c to the length (or diagonal) l of the negative made, then if $C = l/1000$,

$$H = \frac{1000f^2}{nl}$$

In either case, the figure 1000 may be increased or decreased to set any desired standard of sharpness. (See HYPERFOCAL DISTANCE.)

Depth of focus formulæ are many: the fundamental ones are:

$$\text{Near Depth} = \frac{u\,f^2}{f^2 + nc(u-f)}$$

$$\text{Far depth} = \frac{u\,f^2}{f^2 - nc(u-f)}$$

where near and far depths respectively show the distances, from the node of admission of the lens, of the nearest and furthest objects delineated on the negative with a circle of confusion not larger than c, the lens being focused on a distance u.

In terms of H, these formulæ become:

$$\text{Near depth} = \frac{Hu}{H + (u-f)}$$

$$\text{Far depth} = \frac{Hu}{H - (u-f)}$$

the value of c now being that assumed in calculating H.

The limits of depth may also be written

$$\text{Near depth} = u - \frac{ncu(u-f)}{f^2 + nc(u-f)} = u - \frac{u(u-f)}{H + (u-f)}$$

$$\text{Far depth} = u + \frac{ncu(u-f)}{f^2 - nc(u-f)} = u + \frac{u(u-f)}{H - (u-f)}$$

If the limits of depth are to be u_1 and u_2, then the camera must be focused on a distance u such that:

$$u = \frac{2u_1 u_2}{(u_1 + u_2)}$$

and the lens must be set to a stop

$$n = \frac{(u_2 - u_1)f^2}{2u_1 u_2 c}$$

If $c = f/1000$, this becomes $n = \dfrac{1000(u_2 - u_1)f}{2u_1 u_2}$

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All the above formulæ concerning depth of focus apply only when the entire lens is moved forward for focusing. When focusing is done by front cell, or by adding supplementaries, replace $(u-f)$, whenever it occurs, by u. (See DEPTH OF FOCUS.)

Lens-Hood. Any form of tube or hollow box placed over the front of the lens to shield it from light coming from objects outside the field of view. The importance of a hood is two-fold. First, it protects the lens from any bright light (*e.g.*, the sun) that may be outside the field of view, the light of which, illuminating any dust or imperfections of surface on the lens or filter, would be scattered into the interior of the camera. Secondly, it must be borne in mind that the total field of view of any lens always includes a wider angle than is to be recorded on the negative. The image corresponding to the marginal portions of the more extended field falls on the inside of the camera, which, however carefully blackened, will still reflect a good deal of light on to the sensitive surface. General fog, resulting in a degradation of the image, will arise from either of these sources of stray light. Both can be eliminated by the use of a suitable hood. (See REFLECTION IN LENSES.)

Hoods are of several forms, the most common being a plain tube, the diameter of the lens, blackened inside. In some patterns the lower side of this is cut away to avoid the reflections that might arise if the camera was so held that direct sunlight could penetrate a little way into the hood; while advantageous in these circumstances, such a hood must obviously admit light from below, which may be inadvisable when photographing over snow or water. In its extremest form, a cut-away hood becomes merely a skyshade.

Another form consists of a rectangular tube with a front opening similar in shape to the negative; in general, the shorter side is rather larger than the diameter of the lens, Such a hood is obviously more efficient than a simple tube. but its extra size is a disadvantage. Either the rectangular or the circular tube may be flared out to reduce bulk, and in either case a long tube of wide diameter is more effective than a shorter tube of smaller diameter. Wherever possible a hood should be lined with black velvet, which reflects very much less light than even the best deadblack paint. (See also BLACKING.)

The types of hood mentioned above are best suited to cameras with a single fixed lens and without rising front.

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For reflex or stand cameras a very versatile hood may be made by joining two wooden or metal frames by bellows, and arranging variable extension by joining the two frames by lazy-tongs stiff enough to hold the front frame in any position at which it may be set. The back frame is screwed to the camera-front round the lens. In use, the extension of the hood may be varied to suit the field of view of the lens in use.

A convenient and portable lens-hood of high efficiency may be made by cutting a piece of wood to the exact shape of the picture taken by the camera, and of a size such that the width of the wood is about double the external diameter of the lens. A hole to fit the lens is cut centrally in this, and a long temporary straight-sided hood is built out from it in black paper. This is then trimmed down until the edges of the picture are just not darkened, after which the overall width of the paper (from front edge to back of wooden rectangle) is noted, and the paper stripped off and discarded. Four pieces of thin wood, metal, or card are then cut, each having a width equal to the distance just measured, their lengths being equal to the sides of the wooden rectangle. After lining these four pieces with black velvet, they are hinged together with surgical tape to form a rectangular tube fitting over the original piece of wood, the hinging being loose enough to enable this tube, detached from the rectangle, to collapse flat for the pocket or camera-case. As an additional refinement, the wooden rectangle may be equipped with a frame into which light-filters can be slipped when desired.

Still greater efficiency can be obtained by shortening, or preferably widening, the hood a little, and closing its far end with a rectangle of black card in which is cut an opening the shape of the negative, leaving a width of perhaps quarter of an inch all round. This will help to protect the inner surfaces of the hood from light which could be reflected into the lens.

It may be added that a lens-hood should be used for all exposures made out of doors, and that much of the value of a lens-hood is lost if it has to be discarded whenever a light-filter is in use.

(See also Reflection in Lenses and Sky-Shade.)

Lens, Loss of Light in. See Loss of Light in Lenses.

Lens, Reflection in. See Reflection in Lenses.

Light. A form of energy emitted as radiation from luminous bodies, and reflected in some measure from the

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surface of any body on which it falls. The velocity of light *in vacuo* is about 186,000 miles per second, which is also that of cosmic rays, X-rays, γ-rays from radioactive bodies, ultra-violet and infra-red radiation, and wireless waves. All these are electromagnetic waves of the same general type, differing only in wavelength. What we call " visible light " is one tiny fraction of this immense spectrum, to most of which the eye is completely insensitive.

Visible light covers the range of wavelengths from 4000 Angstrom units (A.U.) to about 7200 A.U., the shortest wavelength corresponding to violet and the longest to red. Between these come blue, green, and yellow sensations in order of wavelength. Those colours can be seen in order in the rainbow, which is a spectrum, formed by refraction and reflection in rain-drops, of the white light which is of course a mixture of light of all wavelengths. In a brilliant " normal " spectrum (*i.e.*, one in which the colours are evenly spaced according to their wavelengths) the part that seems most brilliant to the average observer is the yellow-green (about 5500 A.U.) but this visual maximum drifts towards the blue-green (about 5300 A.U.) on reducing the overall intensity (Purkinje phenomenon).

Whatever may be its colour, light, like other electromagnetic waves, travels in straight lines unless deflected through reflection or refraction by some material body, or by passage through a gravitational field. A transparent body is one that allows the bulk of the light falling on it to pass without being scattered (though it may be deflected from its path); clear glass is a typical transparent material. If a body passes the bulk of the light falling on it, but at the same time scatters it as does ground glass, it is called translucent. All surfaces reflect light to some extent; a black body reflects but little, a white opaque body reflects most of the light that falls on it. In either case the reflected light is scattered unless the surface is highly polished. A polished body gives rise to *specular* reflection; the light is reflected but not scattered. In the case of a plane surface this condition gives rise to a visible (virtual) image, as in a mirror, which is the typical case of specular reflection. Specularly reflected light, especially at certain angles, is highly polarised; hence the use of a polarising filter (*q.v.*) over the lens of the camera for reducing the effect of reflections from the surface of glass or of any polished object that is to be photographed.

A coloured object is one that reflects or transmits light to

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a different extent according to its wavelength. A piece of blue paper for example, absorbs red and yellow light more, and reflects it less, than it does blue light. In this way it upsets the balance of the white light incident on it, and the reflected light appears blue. A yellow filter absorbs chiefly blue light ; the light it transmits is therefore deficient in blue, and so appears yellow.

When a ray of light passes from one transparent medium to another in which it is propagated with a different velocity, it is refracted, or changed in direction, to an extent depending both on the angle at which the ray meets the surface and on the relative velocities in the two media. The refractive index of the surface is the ratio between the sine of the angle of refraction and the sine of the angle of incidence, and depends on the wavelength of the light considered and on the nature of the two media, but not on the angle at which the ray strikes the surface. Since the refractive index depends on wavelength an incident ray of white light becomes, after refraction, a narrow strip showing, in order, the colours of the spectrum. (See also CHROMATIC ABERRATION and SPECTROSCOPE.)

Ultra-Violet and Infra-Red Light.—The optical glass normally used in the construction of photographic lenses passes ultra-violet light from the end of the visible spectrum at about 4000 A.U. as far as about 3500 A.U., and as the photographic emulsion is sensitive over this range of wavelength care has to be taken to exclude this light in photographing subjects where it is plentiful. As the dust and water-vapour present in the air scatter and absorb it, ultra-violet light is only present in sufficient amounts to be harmful on very clear days at sea-level, or at high altitudes (above some 6000 feet). In such circumstances it should be excluded by a U.V. filter if it is desired to obtain photographs not showing the characteristics associated with the use of the ordinary yellow filter ; where a yellow filter is to be used the U.V. filter is of course unnecessary. If not excluded in one of these ways, the ultra-violet light may make its presence felt as a haze covering all distant objects, and, since lenses are not in all cases fully corrected for short wavelengths, there may also be a slight degradation of definition.

Ultra-violet light is particularly dangerous in colour photography, as it is recorded by the blue-sensitive emulsion layer and gives the transparency an overall blue cast. Many expert

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colour workers use a U.V. filter for every exposure. Lenses differ in the amount of ultra-violet light they pass; in general, the more complex the lens, and the more components in it, the less the need for a filter.

Besides passing a little ultra-violet, lenses also pass infra-red light. To this, however, the photographic emulsion is completely unresponsive unless specially sensitized. Special films and plates sensitive to infra-red are offered by several manufacturers. When used without a special filter they give results not appreciably different from those taken with ordinary emulsions, but by using a filter excluding all visible light, and passing infra-red only, very unusual photographs can be obtained. Green foliage, which reflects infra-red light freely, appears white, or practically so, in the print, and a blue sky appears completely black. Since the light scattered by dust-particles and water-droplets suspended in the air is chiefly of short wavelength, it is possible to " cut through " quite a considerable amount of haze by photographing with infra-red light. By taking advantage of this some amazingly clearly-defined photographs of very distant objects have been made.

Sources of Light.—The composition of the light emitted by any incandescent body depends fundamentally upon its temperature, and the higher the temperature the greater the proportion of light of shorter wavelengths. The sun, being hotter than any terrestrial body, gives a light richer in blue and violet than that from any incandescent body (gas mantle, electrically-heated filament, etc.) used for the production of artificial light.

A large amount of violet and ultra-violet light, however, is emitted by certain types of electrically-excited gas discharge tubes, such as the familiar mercury arc used both photographically and as a source of artificial sunlight. Such sources as this do not emit the continuous spectrum characteristic of a body that derives its light merely from its high temperature, but give out instead a " line spectrum." This consists of light of a series of isolated wavelengths, the actual wavelengths being dependent upon the gas contained in the tube.

The composition of the more usual types of light in terms of the three regions of the spectrum obtained by dividing it arbitrarily into blue-violet (4000 to 4950 A.U.) green (4950 to 5800 A.U.) and red (5800 to 7000 A.U.) is given in the following table, taken from Clerc's *Photography*:—

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Source.	*Red.*	*Green.*	*Blue.*
Daylight	33·3	33·3	33·3
Metal-filament electric lamp .	61	32	7
Half-watt electric lamp . .	50	30	20
Incandescent gas-mantle . .	54	38	8
Low-voltage arc, ordinary carbons	50	32	18
Low-voltage arc, impregnated white-flame carbons . .	40	35	25

See also COLOUR-TEMPERATURE.

Light, Artificial, for Photographic Purposes. See FLASHLIGHT : FLASHBULB : FLASHGUN : PHOTOFLOOD, STUDIO LAMP and ELECTRONIC FLASH; also see COLOUR-TEMPERATURE, and under ENLARGING and PROJECTOR.

Light-Fog. See FOG.

Lighting of Sitters. See PORTRAITURE.

Lightning, Photography of. Lightning can only be photographed at night, because the duration of a flash of lightning is so short that the shutter could not be opened quickly enough to catch its image, so the camera has to be set up and the lens remain uncovered till the flash has occurred, and then closed. This could, of course, not be done in daylight.

Lightning photographs may be taken out of a window facing the storm : one naturally requires a window with a fair expanse of view. There is usually a good deal of reflected lightning between the flashes actually visible : a photograph of this would only appear like a photograph of the same scene taken by daylight with very much too short an exposure, and a sky lightened in places. This reflected light affects the plate to a certain extent each time it appears, but no harm will be done by three or four even fairly brilliant flashes.

In order, however, to reduce its effect on the plate as far as possible, it is wise to use a fairly small stop, say *f*/11 or *f*/16. The visible flashes are so intensely vivid that a small stop is quite sufficient.

The camera should be so placed as to include a portion of the horizon ; this gives the picture a greater reality, and when the lightning really strikes the ground, the actual spot can be afterwards traced.

It is now recognised that what appears to the eye as a single flash is usually a number of flashes in rapid succession ; the

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air ionized by the initial flash becomes a more ready conductor of electricity, and a damped oscillatory discharge takes place along the path that the initial flash marks out. A multiple flash can be analysed by swinging the camera, so that each successive discharge falls at a different point on the film. This gives greater information concerning the flash, at the cost of losing the background.

Light Trap for Dark-Room. See DARK-ROOM.

Line Drawings, To Copy. See COPYING.

Line Drawings from Prints. See DRAWINGS FROM PHOTOGRAPHS.

Linen, Photographs on. See SILK, PRINTING ON.

Lines per Millimetre. See RESOLVING POWER.

Lippmann's Process. See COLOUR PHOTOGRAPHY.

Litho-Photogravure. A method of Eckstein, in which a photolithographic transfer is put down on a stone ruled with a system of very fine lines; these serve to break up the gradation into a printing grain, and provide for the rendering of half-tone.

Litre. The standard measure of capacity in the metric system; originally intended to have a direct relation (through the metre) to the meridian circumference of the earth, but it is now an arbitrary measure. According to our present legal definition (Statutory Rules and Orders, 1898, No. 411), "Approximately one litre equals 1000 cubic centimetres, and one millilitre equals 1·00016 cubic centimetres." The statutory definition (*loc. cit.*) of the relation of the pint to the litre is "1 litre = 1·75980 pints," each litre is thus 35·196 fluid ounces. (See CUBIC CENTIMETRE; also WEIGHTS AND MEASURES.)

Liver of Sulphur. See POTASSIUM SULPHIDE, and also TONING.

Logarithm. The formal definition is: the logarithm of a number to a given base is the power to which the base must be raised to equal the number. To give an example, 10,000 equals 100^2; the logarithm of 10,000 to base 100 is therefore 2. It is equally true that 10,000 equals 10^4; the logarithm of 10,000 to base 10 is therefore 4. The logarithm of a number thus depends, not only on the number itself, but also on the base to which it is referred.

In practice, only two bases are in common use. For

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everyday purposes, the base taken is 10, giving "common logarithms"; to this base the logarithm of 10 is 1, that of 100 is 2, that of 1000 is 3, and that of 10,000 is 4. The logarithm of any number between 10 and 100 lies between one and two; it will be "one point something." That of 20, for example, is about 1·3. Tables of logarithms can be bought from any scholastic bookseller for a shilling or so, and provide an invaluable short-cut to calculations of all kinds. Inexpensive tables can be had, under the title *Four-figure Tables and Constants for the Use of Students*, from H.M. Stationery Office at 3d. post free.

Their use for abbreviating arithmetic depends on the fact that log ab = log a + log b, and log a/b = log a − log b. To multiply two (or more) numbers, look up in the tables the logarithms of the numbers in question, add the logarithms, and find, again from the tables, the number corresponding to the result. This number is the answer sought. If it is necessary to divide by any number, subtract its logarithm instead of adding it.

The use of logarithms for finding powers or roots depends on the fact that $\log(x^n) = n \log x$, and $\log (\sqrt[n]{x}) = \frac{1}{n} \log x$.

Thus to find, say, the fourth power of a number, look up the logarithm of the number, multiply it by four, and find the number of which the result is the logarithm. This number is the required answer. If the fourth root is required instead of the fourth power, divide by four instead of multiplying by it. Fractional powers and roots are handled just as simply as integral ones.

The logarithm of one is zero, so that logarithms of all numbers less than one are negative. For convenience in calculation, the "mantissa," or decimal part of the logarithm, is always kept positive, so that the logarithm of 0·2, which is −0·7, is written as −1 + 0·3. This lines up with the logarithms of 2 and 20, respectively 0·3 and 1·3.

When logarithms are used simply as an aid to calculation, those to base 10 are always used. If it is desired to be specific, the logarithm of x to base 10 is written $\log_{10} x$, but it is usually sufficiently clear simply to write "$\log x$." In connection with certain natural phenomena, such as the cooling of a heated object, the discharge of an electrical condenser, or the rate of development of a film, or in any process where the rate of progress at any instant depends on the distance still to go, logarithms to the base 2·71828··· (the decimal never ends)

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make their appearance. This apparently inconvenient number is not chosen by the mathematician; it is thrust upon him by the very nature of the problem itself. Logarithms to this base are therefore called "natural logarithms," and the base itself is universally referred to as e. The natural logarithm of x is accordingly written $\log_e x$ (sometimes $\log_\epsilon x$), or, for convenience in writing and printing, as $ln\ x$, where "ln" may be taken as standing for "logarithm, natural."

If a formula contains a logarithm to base e, and no tables of natural logarithms are available, it is worth noting that the natural logarithm of a number is equal to its common logarithm (to base 10) multiplied by 2·3026.

Logarithmic Scale. A scale divided according to the logarithms of the numbers marked, instead of according to the numbers themselves. This gives a scale equal distances along which correspond to equal percentage increases in the numbers. The exposure-scale of an exposure-calculator is an example of this; a succession of equal steps corresponds to repeated doubling of the exposure. The scales of a slide-rule are also logarithmically graduated.

The term is also sometimes applied to a series of numbers having the same characteristic—British Standard or DIN speed numbers, in which each addition of three units marks a doubling of film speed, are an example. (See SENSITOMETRY).

Loss of Light in Lenses. In passing through a lens, light is lost both by absorption and by reflection. The former loss is small, amounting only to some 2.4 per cent. for each centimetre thickness of glass traversed. Even if the total thickness of glass were as much as 1½ inches, this would only lead to a loss of 8½ per cent. of the total light.

Loss by reflection is much more appreciable. It depends on several minor factors, but the most important factor influencing it is the number of air-glass surfaces. This is equal to double the number of separate component glasses, counting a cemented doublet or triplet as a single glass. Each such glass, if uncoated, causes the loss of just over 10 per cent. of the light striking it, passing therefore just under 90 per cent. The following table (adapted from L. P. Clerc's *Photography*) gives the losses due (*a*) to reflection alone, and (*b*) to reflection and absorption combined, in a series of lenses of total glass-thickness 3 cm. and with numbers of uncoated component-glasses from one to five.

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Components . . .	1	2	3	4	5
Reflection loss (per cent.)	11·3	19·6	27·9	35·4	42
Total loss (per cent.) .	12·2	21·1	30	38	45
Total transmission (per cent.) . . .	87·8	78·9	70	62	55

It will be seen that a 5-component lens of total thickness 3 cm. requires practically double the exposure that would be needed by a lens of the same nominal aperture, if it could be made free from these losses. This explains why, until the introduction of coating, every effort was made by designers to keep the total number of components down to three, even at the cost of making the individual components very complex. Now up to six coated components are used in some of the faster lenses, and much of the recent advance in lens-performance must be ascribed to the use made by lens-designers of the freedom conferred on them, by coating, to use so large a number of components. (See also COATED LENSES and REFLECTION IN LENSES.)

Low Key. Term applied to a photograph in which all, or practically all, the tones are deep or dark.

Lumen. Rate of flow of light energy. If a light-source of intensity one candela were placed at the centre of a sphere of radius one metre the total light-power falling on the interior of the sphere would be one candle-power, but the light-power *per square metre* would be a most inconvenient fraction of this. As it is light per square metre that is most often needed in practical work, the light-power per square metre in the sphere above described is christened the *lumen*, and so the fraction is neatly avoided. The lumen is a smaller unit than the candle-power; one candle-power equals 4π (or 12·56) lumens. (See also CANDLE-POWER and CANDELA. Also LUX.)

Lumen-Second. A measure of a total amount of light energy. It is the amount of light energy radiated by a source of power one lumen (about one-twelfth of a candle-power) in a period of one second. (See also LUMEN, CANDLE-POWER, CANDELA, STILB. Also LUX.)

Luminance. Brightness; the luminous intensity radiated per unit area of a surface. The unit is the stilb (*q.v.*).

Luminosity. A term used to indicate the amount of light emitted from unit area of a source of light, or reflected from unit area of an illuminated object. The following table (from Clerc's *Photography*) gives typical values for the relative

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luminosities, or brightnesses, of the various parts of different subjects.

Subject.	*Range of extreme luminosity.*
Interior, with window showing sunlit landscape	1000 to 1
Portrait, artificial light, white clothes	100 to 1
Landscape with white sunlit area and dense foreground shadows	60 to 1
Lampblack on white paper	20 to 1
Landscape in diffused light, dark foreground	15 to 1
Interior, no windows or reflections in field of view	10 to 1
Landscape in misty weather	2 to 1

Blacks are less black, and whites less white, than is usually realised. The whitest substances known reflect but 88 per cent. of the incident light; white paper reflects only some 70 per cent. Ordinary black paper may reflect up to 10 per cent. of the incident light, while an average "black" object reflects perhaps 4 per cent. A sunlit black object may reflect more light than a white one in the shade; in a photograph, the latter would accordingly come out darker than the former.

The range of luminosities available for photographic reproduction is considerably less than that of the average subject. In a black-tone matt print the maximum available range is of the order of 20 to 1, but is greater (up to 50 to 1) in a glossy print. With a P.O.P. print, gold-toned and glazed, the range obtainable is reputed to be as high as 100 to 1. The increase of range as gloss increases supplies the reason for the practice of "doping" matt prints, and for the popularity of those varieties of printing paper which, though not actually glossy, have a surface with a distinct sheen.

In a transparency the range of tones is much less limited, and may often exceed 200 to 1. As might be expected from this high figure, a well-made transparency or lantern slide, viewed either in the hand or by projection, is capable of giving a far more convincing representation of the original subject, especially if this embraced a wide range of contrast, than can ever be achieved by a print on paper.

More recent results in this field will be found in a paper by L. A. Jones and H. R. Condit, entitled "The Brightness Scale of Exterior Scenes etc." (*J. Opt. Soc. Amer.*, **31**, 651 (1941)).

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Lux. Unit of illumination, or of the light per unit area falling on a surface. If the amount of light falling on a surface is one lumen (*q.v.*) per square metre, the illumination on the surface in question is one lux. As this is the illumination on a surface placed at one metre from a source of intensity one candela, the term *candela-metre*, or sometimes *metre-candela*, is often used in place of "lux." The two are synonymous. The lux is sometimes also used as a unit of brightness. (See LAMBERT.)

See also LUMEN, CANDELA, STILB, CANDLE-POWER. Also ELECTRIC LIGHT.

Lux-Second. Unit of exposure. See CANDELA-METRE-SECOND.

Lunar Caustic. See SILVER NITRATE.

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M

M. See M-Synchronization.

Mackie Line. A fault due to insufficient agitation of the solution while developing a film. Where a dense highlight is being developed, the developer becomes exhausted and loaded with reaction products that slow development; these diffuse over the edge of the highlight and retard development all round its boundaries. In the print, therefore, the highlight is surrounded by a dark edge known as the Mackie line. Advantage is taken of this effect in high-definition developers (*q.v.*).

Macro-photographs. Term applied to photographs of small objects reproduced at or about natural size. Macro-photography occupies a position intermediate between ordinary photography, in which objects are much reduced, and photo-micrography, in which objects are shown greatly enlarged.

Magic-lantern. See Projector; also Condenser.

Magic Pictures. These can be prepared by a process invented by Sir John Herschel. A print on albumenised paper is fixed without toning, and washed. Immerse the print in a saturated solution of mercuric chloride until the image is thoroughly bleached and disappears, wash and dry. To make the invisible image appear, place over it a wetted sheet of blotting paper which has been previously soaked in a saturated solution of hypo, and press the hand upon it, when the image will appear with more than its original vigour.

Magilp or Megilp. An artist's material, made by mixing linseed oil with mastic varnish. It is used for thinning oil colours and for glazing delicate tints on finished oil-paintings. Megilp is also used as a medium in the oil and

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bromoil processes (*q.v.*), and may be employed to increase the brilliancy of matt-surface prints. In the latter case it is simply rubbed on to the surface of the dry and finished print, which is then polished by the application of a dry soft rag. Bromide prints which are strong in tone and have been sulphide toned are greatly enhanced in appearance by being given a slight gloss with megilp.

Magnesium (Fr., *Magnésium ;* Ital., *Magnesio ;* Ger., *Magnesium*). Mg = 24. Occurs in large quantities as dolomite or mountain limestone—an impure carbonate. The metal is silvery white in colour, and is met with commercially in the form of wire, ribbon, and powder. It has been used in photography as an illuminant, as the metal ignites at a comparatively low temperature, giving an extremely actinic and brilliant light. In the form of an alloy with aluminium, it provides the inflammable material in many modern flashbulbs.

Weights of Magnesium Ribbon ($\frac{1}{12}$ in. wide).—5 in. = 1 gr.; 8 in. = 0·1 gm.; 80 in. = 1 gm. See instructions for using magnesium under the heading FLASHPOWDER.

Magnesium has been suggested as a means of precipitating silver from old fixing baths. (See RESIDUES.)

Magnification. In photography, generally used to mean ratio of size of enlarged image to that of the negative. Magnification is measured in diameters; that is, by the linear ratio. An enlargement of two diameters is twice as long as the negative; it is therefore also twice as wide, and has four times the area. A whole-plate print from a quarter-plate negative is enlarged two diameters.

The magnification required to obtain a 12 × 10 print from a $3\frac{1}{4} \times 2\frac{1}{4}$ negative is less simply stated, for paper and negative are of different shapes, the former being squarer. If the whole negative has to be printed, its length will have to be brought up to the length of the paper, for which a magnification of $\frac{12}{3\frac{1}{4}}$ or 3·7 diameters is needed. This brings the width of the negative to $3{\cdot}7 \times 2\frac{1}{4}$ or 8·3 in., which does not fill the full width of the paper. If it is required to make the print of full 12 × 10 size, the width of the negative will have to be brought up to the width of the paper; magnification needed therefore is $\frac{10}{2\frac{1}{4}} = 4{\cdot}45$ diameters. The full length of the projected image will then

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be $4{\cdot}45 \times 3\frac{1}{4} = 14{\cdot}4$ in., which cannot all be included on the paper.

The table attached gives the two figures for magnification corresponding to each of a number of combinations of negative and paper sizes. In every case the smaller figure is that for printing the whole negative, and the larger for filling the full area of the paper. Where the two are the same, negative and paper are of the same shape.

More generally, the term magnification means ratio of the size of the image to that of the object. In most photographic work, the image is smaller than the object; the magnification is then a fraction. If an object 50 in., long is reproduced on the film as 1 in., long, the magnification is 1/50. This is often expressed by saying that the reduction is 50 times, or 50 to 1. See LENS FORMULÆ, also CONJUGATE FOCI, ENLARGING, and COPYING.

MAGNIFICATION IN DIAMETERS

Size of Negative.	SIZE OF PRINTING PAPER (INCHES).								
	3¼×2¼	4¼×3¼	5×4	5½×3½ (P.O.)	6½×4¼	8½×6½	10×8	12×10	15×12	20×16
18×24 mm. ..	3·53 3·71	4·50 4·60	5·29 5·65	4·05 5·84	6·66 6·88	9·00 9·15	10·6 11·3	12·7 14·1	15·9 16·9	21·2 22·6
24×24 mm. ..	2·65 3·71	3·44 4·50	4·23 5·29	3·71 5·84	5·00 6·88	6·88 9·00	8·45 10·6	10·6 12·7	12·7 15·9	16·9 21·2
24×36 mm. ..	2·47 2·65	3·00 3·44	3·53 4·23	3·71 3·89	4·59 5·00	6·00 6·88	7·05 8·45	8·46 10·6	10·6 12·7	14·1 16·9
3×4 cm. .. (Half-V.P.) ..	2·12 2·22	2·70 2·75	3·18 3·38	2·97 3·50	4·00 4·13	5·40 5·50	6·35 6·77	7·63 8·47	9·54 10·2	12·7 13·5
4×4 cm. ..	1·59 2·22	2·06 2·70	2·54 3·18	2·22 3·50	3·00 4·13	4·13 5·40	5·08 6·35	6·35 7·63	7·63 9·54	10·1 12·7
4·5×6 cm. .. (16 on 120) ..	1·41 1·48	1·80 1·83	2·12 2·26	1·98 2·34	2·67 2·75	3·60 3·66	4·23 4·51	5·09 5·65	6·35 6·79	8·47 9·05
4×6·5 cm. .. (V.P.) ..	1·37 1·59	1·66 2·06	1·95 2·54	2·16 2·22	2·54 3·00	3·32 4·13	3·91 5·08	4·70 6·35	5·85 7·63	7·81 10·1
6×6 cm. ..	1·06 1·48	1·38 1·80	1·69 2·12	1·48 2·34	2·00 2·75	2·75 3·60	3·39 4·23	4·23 5·09	5·09 6·35	6·77 8·47
3¼×2¼ in. ..	1·08 1·11	1·31 1·44	1·54 1·78	1·56 1·70	2·00 2·10	2·62 2·89	3·08 3·55	3·70 4·45	4·61 5·35	6·15 7·10
3¼×2½ in. ..	1·00 1·00	1·21 1·30	1·43 1·60	1·40 1·57	1·85 1·90	2·43 2·60	2·86 3·20	3·43 4·00	4·29 4·80	5·71 6·40
4¼×3¼ in. ..	0·77 0·82	1·00 1·00	1·18 1·23	1·08 1·29	1·46 1·53	2·00 2·00	2·35 2·46	2·82 3·08	3·53 3·69	4·70 4·92

Magnifier. Term sometimes used for supplementary lens (*q.v.*). A focusing magnifier is a lens used for examining the image on the focusing screen for more precise focusing.

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Marginal Cut-off (of Light). See WIDE ANGLE.

Marine Glue. For repairing the leather work of cameras nothing is better than marine glue, which is also useful in many other ways for repairing wood, etc. It is made thus :—

Indiarubber in fine shreds	60 gr.	(7 gm.)
Coal-tar naphtha	1½ oz.	(75 c.c.)

Digest with heat and frequent stirring until dissolved, and then add

Shellac in powder	2½ oz.	(125 gm.)

After adding the shellac, heat and stirring must be continued until the whole is quite fluid, then pour it out on to a cold slab to set. When required for use it should be melted at a temperature not exceeding 250° F., or it is liable to lose its strength. It may be applied with a bristle brush, and should be used as thinly as possible.

Masking. Term used to indicate the blocking out of part (usually the edges) of a photographic image. Masking may be used simply to provide a white edge to a print or enlargement, or, as in a lantern slide, to limit the picture-area to part only of the total available area. The procedure described in *Simultaneous Exposure and Development*, under ENLARGING, is also a form of masking, the initial image of the shadow portions of the picture being used as a mask during the second exposure.

Masks, in the form of a positive of low density and contrast bound up in register with the original negative, can be used as a safe means of reducing the contrast of an over-contrasty negative, while if a second negative is made from the positive and is bound up with the original negative, contrast can be increased. In colour work, a weak monochrome negative is often made from a colour transparency and bound up with it to reduce overall contrast without reducing colour saturation; from the combination colour separation negatives are made. For colour masking to control colour rendering, see COLOUR PHOTOGRAPHY.

(See MASKING FRAME, and *Shading and Double Printing*, under ENLARGING. Refer also to UNSHARP MASKS.)

Masking Frame. An accessory used with vertical enlargers to hold the paper flat and provide a white border. The

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simplest type consists of a frame to take the paper, and a rectangular mask of fixed size hinged to it. In the adjustable, or universal, frame a baseboard is provided, and two sides of the mask are moveable so that any size or shape of opening can be produced. The frame as a whole is hinged, and adjustable stops against which the edge of the paper is located are provided below the two fixed sides of the mask. A number of prints identically masked can be made rapidly and readily with one of these frames. (See ENLARGING.)

Matt Surface. A term applied to all dull-surfaced prints as distinguished from those with a glossy or glazed surface.

Matt Varnish. See VARNISH.

Mealiness (of Prints). A peculiar mottled-grey appearance that occasionally disfigures a print. Generally it only appears, or is most marked, at the edge of the paper, and it is normally due to deterioration of the paper by age or improper storage. If the paper has not deteriorated too far, mealiness can be reduced or eliminated by adding an anti-foggant (" developer improver ") to the developer and developing the paper for the minimum time necessary to give a good black, adjusting the exposure to suit this treatment. In a bad case, the paper must be treated as fogged. (See *Restoring Old and Spoilt Bromide Paper*, under BROMIDE PAPER.)

Measure. A vessel, usually of glass, graduated in fluid ounces or cubic centimetres, for the measurement of volumes of water or solutions. Small measures are usually conical in shape, but those graduated for maximum volumes over 2 oz. or 50 c.c. are generally shaped more or less like a tumbler. All have lips for pouring. A *measuring cylinder* is a tall, narrow measure with straight sides.

Measures. See WEIGHTS AND MEASURES.

Meniscus. See LENS.

Mercuric Chloride (Fr., *Bichlorure de mercure ;* Ital., *Bicloruro di mercurio ;* Ger., *Quecksilberchlorid, Mercurichlorid, Sublimat*). $HgCl_2 = 271$. Synonyms : Perchloride of Mercury, Bichloride of Mercury, Corrosive Sublimate, Sublimate, Muriate of Quicksilver. It is prepared commercially by sublimation from a mixture of mercuric sulphate and common salt. It is usually met with in commerce in extremely heavy colourless crystalline masses or as a white powder. Specific

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gravity: 5·43. Solubility: 1 in 19 of cold, 1 in 3 of hot water, 1 in 5 of rectified spirit, 1 in 6 of ether. It sublimes without decomposition, and melts at 530° F. It is used for intensification (*q.v.*). Its solution in water is liable to decomposition; but any soluble chloride tends to prevent this, and nearly all chlorides increase its solubility in cold water, a compound salt being formed. It is a powerful poison, 3 gr. (200 mgm.) being a fatal dose. The antidote is albumen, or white of egg, with which it forms an insoluble compound, followed by emetics. As the salt is readily absorbed by the skin, it is advisable to exercise care.

Mercuric Iodide. (Fr., *Bi-iodure de mercure;* Ital. *Bi-ioduro di mercurio;* Ger. *Quecksilberjodid, Mercurijodid.*) $HgI_2 = 454·5$. Synonyms: Periodide of Mercury, Bi-iodide of Mercury. Heavy red amorphous powder, practically insoluble in water. Dissolves readily in solutions of iodides, sulphites, or thiosulphates (hypo). Poisonous; its properties in this respect are practically as mercuric chloride (*q.v.*). Used as a one-solution intensifier for negatives, having the useful property of intensifying the shadows more than the highlights. (See INTENSIFICATION.)

Mercury (Fr., *Mercure;* Ital., *Mercurio;* Ger., *Quecksilber*). Hg = 200. Synonym, Quicksilver. Occurs native, but is chiefly obtained by treating the ore cinnabar, an impure sulphide. At ordinary temperatures mercury is a brilliant silvery-white liquid metal, becoming solid at −40° F. Specific gravity 13·5. As the vapour of mercury is poisonous if much is inhaled, particular care should be taken that any bottle containing it is really well stoppered. Mercury was used to develop the image on a Daguerreotype plate, but is now of photographic interest only for hypersensitising (*q.v.*).

Mercury Vapour Lamp A lamp containing mercury vapour which is rendered incandescent by the passage of an electric current. The light given by the lamp, which takes the form of sealed glass tubes either singly or in series, is dazzling blue-white in appearance and is lacking in red rays. For use in the studio, this may, however, be corrected by the presence of a few ordinary electric lamps in red globes. The mercury vapour lamp is admirably adapted for artificial light printing, enlarging and portrait work.

Meritol. Combination of paraphenylene diamine and pyrocatechin in molecular proportions, patented by Johnsons

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of Hendon Ltd. Formula $C_6H_4(OH)_2$: $C_6H_4(NH_2)_2 = 218$. Fine white or light grey crystals, turning very dark through exposure to air. Fine-grain developing agent of higher activity than paraphenylene diamine. Although the solid keeps well only if air is totally excluded, the normal developers containing it can be stored for prolonged periods. These developers are often quite deep red in colour, but develop normally unless the colour is very deep indeed. Solubility in 10 per cent. sulphite solution, about 5 per cent. Meritol is produced especially for fine-grain development, and the addition of metol reduces the need for extra exposure without noticeably coarsening the grain, and greatly improves the exhaustion characteristics of the solution. It is the developing agent in the Meritol-caustic two-bath developer. See FINE-GRAIN DEVELOPMENT.

Methylated Spirit. See ALCOHOL, METHYLATED.

Metol. Methyl-*p*-aminophenol $(CH_3NH)C_6H_4OH = 123$. Synonyms: Elon, Monol, Rhodol, Scalol. Known in France as *Génol*. Developing agent of high activity, usually sold in the form of the sulphate (MW = 172). Colourless crystalline needles, soluble in water to the extent of about 5 per cent. at room temperature, and rather less soluble in solutions of sodium sulphite, or carbonate, which liberate the sparingly soluble free base. Sodium sulphite will sometimes precipitate metoquinone when hydroquinone is also present. Insoluble in ether. Will develop slowly in solution with sulphite only (see FINE-GRAIN DEVELOPMENT) but is usually used with an alkaline carbonate. With caustic alkalies is very prone to give chemical fog. Metol is used to some extent by itself, but finds its chief application in mixed developers of all kinds. The metol-hydroquinone (M-Q) developer (see DEVELOPMENT) is probably more widely used than any other, and metol is very commonly added to fine-grain developers in an endeavour to retain the maximum speed of the emulsion. Metol attacks the skin of some persons, causing unpleasant sores. (See SKIN.) This is believed not usually to be due to the metol itself, but to traces of dimethylparaphenylenediamine present as an impurity. (See PHENIDONE.)

Metric System. The system of weights and measures universally used on the continent of Europe. It was established by the revolutionary administration in France towards

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the end of the eighteenth century, the basis of the whole system being the metre. This was intended to be a ten-millionth part of a meridian circle, but the accuracy of measurement available at the time was not high, and the standard must now be regarded as an arbitrary one.

In the metric system the metre is the sole unit of length, even the longest and shortest distances being expressed in terms of it by decimal multiplication and subdivision. A kilometre is 1000 metres (roughly two-thirds of a mile) and a millimetre is $\frac{1}{1000}$ metre or nearly $\frac{1}{25}$ in.

The measures of volume and weight are closely linked to the metre; the litre is practically a cubic decimetre (decimetre = $\frac{1}{10}$ metre) and the gram is the weight of a cubic centimetre of pure water. These again give rise to multiple and submultiple units by decimal multiplication and division —*e.g.* kilogram = 1000 gm., milligram = $\frac{1}{1000}$ gm., millilitre = $\frac{1}{1000}$ litre, etc., etc.

Once the unfamiliarity of the units has been got over, the metric system is far easier to use than the quite irrational English system of weights and measures. For numerical equivalents between British and metric units, see WEIGHTS AND MEASURES.

Micro-. Prefix used in the metric system (*q.v.*) to signify "one-millionth of." For example, a micro-second is one-millionth part of a second.

Microfilm Work. See COPYING.

Micron. A millionth part of a metre, or a thousandth part of a millimetre. Equal to about one twenty-five-thousandth part of an inch.

Micro-Photography. The reproduction of photographs on a very minute scale. The grainless structure of a collodion transparency lends itself particularly well to this work. (For Photo-micrography, see article under that head.)

Milli-. Prefix used in the metric system (*q.v.*) to signify "one-thousandth of."

Millilitre. A statutory measure of capacity equal to one-thousandth of a litre. For all photographic purposes it may be regarded as identical with the cubic centimetre. (See LITRE and CUBIC CENTIMETRE; also WEIGHTS AND MEASURES.

Millimicron. A thousandth part of a micron (*q.v.*), or a

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millionth of a millimetre. Often used in expressing wavelengths of light. One millimicron equals ten Angstrom Units (*q.v.*).

Miniature Cameras. A miniature camera was at one time officially defined by the Royal Photographic Society as a camera making negatives of area not more than six square inches, but in general amateur usage the term is restricted to cameras using 35-mm. perforated film, as standardized many years ago for professional cine work. The usual negative size is 24 × 36 mm., or 1 × 1½ inches, though other sizes (23 × 32, 24 × 24) have made their appearance. The size 18 × 24 mm. also finds some advocates (especially in Japan) but popular usage has not as yet determined whether cameras for this size shall be called " miniature " or " sub-miniature."

At the present time miniature cameras are far more widely used by amateurs than any other type, their only important rival being the twin-lens reflex, usually for negatives 2¼ in. sq. on roll film.

Though small cameras had been made before, for all practical purposes the history of the miniature camera began in 1925 when the Leica, designed by Oscar Barnack and made by Leitz of Wetzlar, in Germany, appeared on the market. At first its progress was slow, partly because of the imperfections of the films of its date and partly because experienced photographers refused to believe that a negative no larger than 24 × 36 mm. could possibly give satisfactory large-scale enlargements. Improvements in films, especially in the direction of finer grain, combined with the ever-growing and ever-improving output of work by the new school of miniaturists, led by about 1930, or soon after, to the acceptance of the Leica as a serious instrument.

Since that date the number of miniature cameras on the market has steadily increased, and practically all now use 35-mm. film for 24 × 36 mm. pictures, though in the late nineteen-thirties inexpensive cameras for negatives size 3 × 4 cm., obtained by making 16 exposures on a 127 film, were very popular.

The reasons for the rapid extension of miniature work are both psychological and technical. The ordinary man, out with his friends, does not wish to take a camera unless it can be unobtrusive to carry and rapid to use. In both these directions the miniature satisfies, and may be used without interference with the convenience of non-photographic members of the party. In addition, the small size of

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most miniature cameras allows them to be carried more or less permanently in the ever-ready case or pocket, ready to deal with any unexpected subject that may present itself.

On the technical side, there are certain advantages inherent in the small size of picture, and the chief of these is speed. On a larger camera, a lens working at *f*/2 would be extremely cumbersome, fabulously expensive, and would give so small a depth of focus that it could be used at full aperture only on rare occasions. A cine-film miniature fitted with an *f*/2 lens can still be slipped into the pocket and while expensive, the price is not altogether prohibitive. Most important of all, the depth of focus is great enough to allow the full aperture of the lens to be used for most ordinary subjects without difficulty ; it is about the same as that of an *f*/5·6 lens on a quarter-plate camera. Fast work in a really bad light, or by artificial light, is therefore made very easy with a miniature camera, while in a good light, when smaller stops may be used, depth of focus is so great that focusing difficulties are practically eliminated.

The number of patterns of miniature camera now on the market is so great that the models offered include nearly every possible design, and they are difficult to classify into types. The simplest models consist of a camera body, having provision for advancing film by the requisite number of perforations after each exposure, with a lens and shutter rigidly mounted in front. Focusing may be by front cell, and the shutter is normally cocked automatically as the film is wound on. This basic type has almost completely replaced the once popular folding camera with bellows; the greater compactness of the latter is not wanted now that cameras are almost always carried in an ever-ready case, and the rigid design lends itself much more readily to the many refinements to be found on the more expensive models.

The great majority of modern manufacturers make use of a diaphragm shutter (Compur, Prontor, etc.) on which the lens is mounted so that the blades of the shutter come between the components of the lens, but in cases where the lens is to be interchangeable it is common for it to be mounted so that, with focusing set to infinity, the blades come immediately behind the back glass of the lens. In all advanced cameras of this type, the whole mechanism centres in the shutter, which is really the heart of the camera. Besides automatic cocking as the film is wound (usually by a single stroke of a lever),

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interlock between shutter release and film-wind is normally fitted. Other refinements may include a coupled range-finder, usually combined with a suspended frame bright-line finder, interlock between stop and shutter-speed so that as either is changed the exposure-value is held unaltered, a built-in exposure-meter, probably coupled to the stop and shutter-speed settings to give semi-automatic or fully automatic operation (see AUTOMATIC CAMERA) and provision for interchangeable lenses with, in one or two cases, a self-adjusting viewfinder that sets itself to show the field of view of the lens in use.

In a few cameras allowing for change of lens, the shutter blades are between the components, and focal length is altered, without shift of focal plane, by removing the normal front component of the lens and replacing it by another. More often the lens is placed entirely in front of the shutter, and the complete lens is removed and replaced. Specially designed lenses are needed for either method; the almost complete freedom to use any lens, if suitably mounted, that is available when a focal-plane shutter is used cannot be had with a Compur-type shutter. The latter, however, has the very great advantage that the use of flash presents no problems, and it allows of the complicated linkages indicated above, many of which are not practicable with a focal-plane shutter. Nevertheless, in the Leica, and some other cameras of the highest grade, the focal-plane shutter is still used; in the view of many the lower degree of automation it permits is more than offset by the much greater versatility a camera so fitted can provide.

In the last few years the single-lens reflex has become a serious competitor of the viewfinder cameras just described. The history of the 35-mm. reflex began in 1937 with the Kine-Exakta of Ihagee (Dresden), which was of more or less conventional reflex design and used a focal-plane shutter. Like all such reflexes, it was awkward to use on its side for upright pictures, but it and its present-day successors, by the same makers or others, undoubtedly remain the most versatile and adaptable of all 35-mm. cameras. Naturally the lenses are interchangeable, extension tubes can be inserted between lens and camera-body for close-up work, and there is no parallax error. In this and other reflex cameras automatic stop-control is usual, allowing focusing always to be done with the lens at full aperture, partly for better visibility but more to allow the use of the twin-wedge " rangefinder " (it is really a focusing

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aid) which is operative only at wide lens-openings. In earlier versions, the lens-aperture was pre-set by setting a stop; after focusing, the aperture-ring was turned as far as it would go, bringing the aperture to the pre-determined size for the exposure without making it necessary to take the camera from the eye. In most current cameras, the aperture is closed automatically to the pre-set opening by a spring as soon as the shutter-release is pressed. Nearly all current focal-plane reflexes can have the focusing screen and hood replaced by a pentaprism (*q.v.*) which allows of eye-level operation, and presents the image right way up and right way round for both horizontal and upright pictures. Recently the "instant return" mirror has been introduced on some models; after the exposure is made the lens re-opens to full aperture and the mirror returns to the viewing position, so that the visual image "blinks" for only a fraction of a second instead of blacking out completely at the instant of exposure.

The year 1953 saw the introduction of the Contaflex by Zeiss Ikon (Stuttgart), a 35-mm. reflex with eye-level pentaprism viewing and a front shutter. This makes for a more compact instrument than does the focal-plane shutter, and solves flash problems; on the other hand it limits choice of lens and in general renders the camera less versatile. Nevertheless it provides a compromise that has proved very popular indeed, and there are now many different models, by many makers, of this general design. A camera of this type depends almost entirely upon its shutter, which is a very complex mechanism indeed; when focusing its lens is at full aperture and the shutter fully open, and on pressing the release the shutter closes, the mirror rises, the lens closes to the pre-set aperture, and then the shutter opens for the exposure. In some models the mirror is lowered, the shutter re-opened, and the lens re-set to full aperture when the film is wound on; in models with "instant-return" mirrors these actions also follow on as part of the train of events set in action automatically by pressing the shutter-release to make the desired exposure.

In all but the viewing system, this type of reflex is closely similar to the viewfinder cameras described earlier, and can be found fitted with coupled exposure-meter and all refinements (except, of course, coupled rangefinder) mentioned in connection with them. It is customary to fit all such cameras with a twin-wedge focusing aid, often referred to in manufacturers' literature as a rangefinder. Part or all of the field of view

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round the focusing aid consists of a ground-glass screen on which focusing can be checked.

Negative Material.—For all 35-mm. miniatures the negative material used is perforated film, of overall width 35 mm. and 24 mm. wide between perforations; this is dimensionally identical with that used in professional cine cameras. It is used, without backing paper, in a cassette (*q.v.*). Traditionally, the length of film is 64 inches, giving 36 exposures each 24 × 36 mm., but colour films (and a few monochrome ones) are sold in 20-exposure lengths. Film can be bought: (*a*) in a cassette ready for loading into the camera; (*b*) as 36 (or 20) exposure-lengths cut and trimmed ready to load, in the dark-room, into a cassette, or (*c*) in tins containing uncut lengths of 5 metres or more. Special self-opening cassettes, indefinitely reloadable, can be bought for some cameras; by eliminating the plush-lined light-trap, they reduce the likelihood of scratching the film in the camera.

See also CAMERA.

Minim. See WEIGHTS AND MEASURES.

Mired. Unit in which colour temperature (*q.v.*) is sometimes expressed. The term is a synthetic one, from " micro reciprocal degrees," and the mired value of a colour temperature is found by dividing the colour temperature, in degrees K, into one million. Thus the mired value of photoflood light (3,400° K) is 294, that from a household lamp (2,900° K) is 344, and that of mean noon sunlight (5,400° K) is 185. The value of the unit lies in the fact that a correcting filter, as used in colour photography, alters the mired value of the light reaching the film by the same amount irrespective of actual colour temperature, whereas the change in degrees K varies according to the initial colour temperature of the light. Similarly equal mired changes in the colour temperature of the light used for colour photography are equally noticeable in the final result. It is usually considered that, for standard colour-reproduction, the colour temperature of the light should be adjusted, by the use of filters, to within 10 mireds of that for which the film is intended by the makers.

Mirror Lens. Also sometimes known as Schmidt lens. In a mirror lens the image is formed by reflection from the surfaces of concave and convex mirrors instead of by refraction through convex and concave lenses. Telescopes have used

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mirrors in preference to lenses for many years, the chief reason being the total absence of chromatic aberration. This advantage is also of considerable importance in very long-focus lenses for ordinary photography, and several makers have adopted this construction for miniature camera lenses of focal length 500 mm. or more. A further advantage is that the lens, though of large diameter, can be comparatively short for its focal length, but it is a serious drawback that such lenses cannot easily be stopped down.

Mirror, Reversing. A silvered mirror with the metal film outwards, placed in front of the lens when laterally reversed negatives are wanted. (See next article; also REVERSED NEGATIVES.)

Mirror, Silvering. To silver a mirror, prepare the following :—

A.	Silver nitrate . . .	60 gr.	(7 gm.)
	water (distilled) . .	4 oz.	(200 c.c.)

To this add 0·880 ammonia drop by drop, and with constant stirring, till the solution turns brown. Continue adding the ammonia till the solution is only slightly milky. Do not add too much ammonia.

B.	Formalin (40% formaldehyde)	8 to 10 drops	
	Water (distilled) . .	4 oz.	(110 c.c.)

Store solution B for a day or two before use.

Clean the glass thoroughly, removing the old silver, if necessary, with concentrated nitric acid applied with a swab of cotton-wool. Finally rinse well with distilled water. Then flow or mop the surface with solution A, leaving it on the glass for at least one minute. Mix about one part of A with two parts of B and pour gently over the glass. Deposition of silver will begin a few seconds after the solutions are mixed, and should be complete in two to three minutes.

Tilt the solution off the glass, rinse well with distilled water, and stand on edge to dry. Finally, protect the silvering with varnish or lacquer.

Monckhoven's Intensifier. See INTENSIFICATION.

Monocular Vision. Seeing with one eye only. Monocular vision can judge the direction, but not the distance of an object.

Montage. See PHOTO-MONTAGE.

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Mountain Photography. See ALPINE PHOTOGRAPHY.

Mountant. The substance used to make a photographic print adhere to its mount. It is absolutely necessary that the mountant should be free from acidity, or stains and spots may arise.

The following mountants are suitable for photographs :—

Dextrine Mountant.—A very adhesive and cheap paste for mounting photographic prints without cockling, and one which keeps in good condition for an indefinite period, is easily made as follows :—1 lb. (500 gm.) of the best white dextrine is mixed a little at a time with cold water until a smooth, cream-like paste is made. About a drachm (4 c.c.) of oil of cloves, oil of cinnamon, or oil of wintergreen is stirred into the paste, and 10 oz. (300 c.c.) of cold water added. The mixture is then placed in a clean enamelled saucepan, and gently boiled until quite clear. It should then be poured into a wide-mouthed jar, covered up, and allowed to set in a cool place. It sets into a firm white paste of the consistency of butter. A very little of this can be spread on the back of a print with the finger-tip or a stiff brush. It should be noted that the best white dextrine must be used.

Starch Mountant.—Starch in powder 1 oz. (30 gm.) : mix into a cream with 1 oz. (30 c.c.) of water, and add to it, constantly stirring, 8½ oz. (250 c.c.) of boiling water in which 20 gr. (1·35 gm.) of common alum and 5 drops of carbolic acid have been dissolved. The mixture should be now a clear translucent jelly free from lumps ; if it is not, it should be gently heated in a dish or pan till it clears, constant stirring being an absolute necessity ; then it should be squeezed through fine muslin.

Ordinary household flour makes a more adhesive paste, but is liable to acidity. Both will keep fit for use about a week, after which they should be rejected.

Gelatine.—This, if properly made, is convenient and easy of application. The print can be mounted whilst still damp, and it can be shifted about on the mount, or any excess of mountant wiped off, without leaving any trace on the mount, even if highly enamelled. The following is a satisfactory method :—Soft gelatine, 200 gr. (30 gm.) ; soak in distilled water (6 oz. or 390 c.c.) for an hour. Dissolve by the aid of a water bath, and add, in small quantities at a time, methylated spirit, 2½ oz. (165 c.c.), stirring constantly ; allow it to set.

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Should any spirit separate out, the mixture should be remelted, and a little more water added. The product should be a pure milk-white firm jelly. A little carbolic acid may be added if desired. When required for use, melt by the aid of hot water on a water bath.

Indiarubber Solution.—

Pure masticated rubber . .	80 gr.	(5 gm.)
Chloroform or benzene . .	8 oz.	(250 c.c.)

Digest till dissolved. Benzene is cheaper than chloroform, but the smell is rather unpleasant.

Warning.—A number of commercial rubber-based mountants have been found to produce reddish stains on prints a few months after mounting, especially at points where a thick layer of rubber has been used or if it has not been allowed to dry sufficiently before laying the print down. In some cases the stains fade away slowly of themselves if the print is exposed to air, preferably after removal from the mount.

(For shellac mountant for dry-mounting, see MOUNTING.)

Mounting is the operation of causing prints to adhere to some substance, such as card, cloth, wood, or glass, either for ornament or the better protection of the print itself.

For exhibition work it has long been the rule that prints shall be mounted on plain boards or stout papers of white, cream or some other pale and unobtrusive tint. For either mounts or albums such a support is almost invariably sufficient and satisfactory for the purpose. Prints may be trimmed to any desired size and proportions, even though there are recognised standard sizes of mounts for exhibition purposes. A safe position of the print on a mount is such that there are margins of equal width at sides and top, with the bottom margin about half as wide again. Variations within limits are permissible, but any eccentricity in the placing of the print should be avoided as being in bad taste.

Partial attachment, which is only adequate when the print is to be framed or shown under glass, is generally carried out by applying adhesive to the top edge only ; by a narrow band round all four edges ; or by small patches near the top corners, or perhaps all four. In all these cases a powerful adhesive is required.

Any aqueous mountant causes the print to expand more or less, and as it dries it contracts so strongly that it curls and distorts the mount. This can be counteracted by sticking

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down on the back of the mount, immediately behind the print, a piece of paper of the same size and thickness as the print itself. Another method is to paste on the back two narrow strips of paper following the diagonals of the mount.

Dry mounting is universally accepted as the most satisfactory procedure. It is carried out by placing between print and mount a thin sheet of unsized paper impregnated with shellac ; the shellac is then melted by heat, and when it hardens again on cooling it cements print and mount firmly together. Firm pressure has to be applied to hold print, shellacked paper, and mount closely together during the few seconds taken by the shellac to harden. For quick and easy mounting a special hot press is required ; this is an expensive piece of equipment.

Amateurs frequently use an ordinary domestic flat-iron, electrically or otherwise heated, for dry mounting. The dry-mounting tissue, as the shellac paper is called, is attached to the back of the print at one or two points by a touch with a hot iron. (An electric soldering iron, under-run to prevent the temperature rising too high, is ideal for this.) Print and tissue are then trimmed together, laid on the mount, and covered with an uncreased sheet of stout paper or a thin sheet of zinc. The print is then " ironed down " by pressing a heated iron on the metal or paper covering the print until the heat has penetrated to the tissue, when it is shifted to a new place ; and so the process is repeated till the whole print has been covered.

The tissue requires to be heated to about 175° F. ; the iron may be heated by keeping it for a few minutes in a saucepan of boiling water. If the tissue adheres to the mount only, the temperature is too high ; if to the print only, it is too low. Both print and mount must be bone dry before mounting is attempted.

The tissue may be replaced by the following preparation, brushed hot over the backs of the untrimmed prints.

White shellac	2 oz.	(60 gm.)
Borax	300 gr.	(20 gm)
Sodium carbonate . . .	60 gr.	(4 gm.)
Water	7 oz.	(200 c.c.)

Place the water in a glass jar standing in a saucepan of water. Bring to the boil, dissolve the borax and the carbonate, and boil for five minutes. Powder the shellac and add it slowly, with stirring ; then boil for an hour.

The outstanding advantages of dry mounting are that there is no tendency to cockle, and that the shellac insulates the

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print from any impurities in the mount, so enhancing permanence.

Moving Objects, Photography of. In taking a photograph of a moving object it is normally desired to obtain a sharp image. This involves the use of a high enough shutter-speed to render the movement of the object during the time of exposure imperceptible on the negative, or on any enlargement that may be made from it. It is evident that the more rapidly the object is moving the shorter must be the exposure.

But it is the image, rather than the object itself, with which we are concerned. The image of an object moving across the field of view moves much more rapidly on the film than does the image of an object travelling at the same speed directly towards the lens. In the latter case, the only thing to be considered is the apparent increase of size as the object approaches, and the exposure can be much longer without blur becoming apparent. Directions of movement between these two extremes will call for intermediate shutter speeds.

The size of the image also enters into the matter ; a car that moved 3 in. during the exposure would look extremely blurred in a photograph taken from so short a distance, or so much enlarged, as to show the driver's face. Yet if the car were shown small enough on the print, as it might be in a street scene where the car was in the background, the blur would pass unnoticed.

In taking this point into consideration we might go into elaborate calculations involving the focal length of the lens and the distance of the object, and work out the shutter speed necessary to reduce the blur on the negative to some predetermined limit. Such calculations are, however, not very helpful in practice, and it is much easier to work out the distance the moving object will travel during the exposure, and, knowing on what scale the object is required to be in the finished print (enlarged or otherwise), to decide whether the blur involved will be enough to matter. If it is found that during the proposed exposure—say $\frac{1}{100}$ sec.—a car moves a distance equal to the diameter of one of its wheels, the amount of blur will be considerable ; if it only moves by the diameter of the hub-cap, it will be fairly sharp. Expressed thus, the amount of blur to be expected at any chosen shutter-speed is quite easy to visualise.

The following table shows the distance in inches moved in different exposure-times by objects travelling at various speeds.

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MOVEMENT OF OBJECT, IN INCHES, DURING EXPOSURE.
Duration of Exposure (sec.)

Speed of object in m.p.h.	1/50th	1/100th	1/200th	1/500th	1/1000th
1	0·36	0·18	0·09	0·036	0·018
2	0·7	0·36	0·18	0·07	0·036
3	1·1	0·54	0·27	0·11	0·054
5	1·8	0·9	0·45	0·18	0·09
7	2·5	1·25	0·62	0·25	0·125
10	3·6	1·8	0·9	0·36	0·18
15	5·4	2·7	1·3	0·54	0·27
20	7·2	3·6	1·8	0·72	0·36
25	9	4·5	2·2	0·9	0·45
30	10·8	5·5	2·7	1·1	0·55
40	14	7	3·6	1·4	0·7
50	18	9	4·5	1·8	0·9
60	22	11	5·4	2·2	1·1
80	29	14	7·2	2·9	1·4
100	36	18	9	3·6	1·8
150	54	27	13·5	5·4	2·7
200	72	36	18	7·2	3·6
300	108	54	27	10·8	5·4

In using the above figures it is only necessary to consider whether the blur involved by the object movement shown is likely to be objectionable, taking into consideration the scale on which the object is to be shown in the finished print and the direction of its movement. It is convenient to reckon that at 50 m.p.h. an object moves an inch in a thousandth of a second; a mental calculation for other speeds and exposure times can be based on this.

It is to be noted that considering blur in terms of the size of the object itself rules out all need to consider either the focal length of the lens or the distance of the object. These affect the size of the image on the *film;* enlarged up (or reduced down) to a constant size in the finished print, photographs taken with any camera or lens, at any distance, will all show identical blur if the exposure-times were the same.

In photographing athletics and the like, allowance will have to be made for arms and legs that may move at least twice as

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fast as does the athlete's body as a whole. Reasonably close-up pictures of athletic sports generally require exposures of $\frac{1}{200}$ to $\frac{1}{1000}$ sec., depending on the size of the figures and the rapidity of their movement.

In this connection the following table may be of value. Though perhaps more convenient for reference, it should be regarded as secondary in importance, and in accuracy, to the method of determining shutter-speeds already given.

SHUTTER SPEEDS REQUIRED FOR MOVING OBJECTS

	25 ft. away.	10 ft. away.
Figures standing, or strolling towards camera	1/50	1/100
Figures strolling across or walking towards camera	1/100	1/250
Figures walking across or running towards camera	1/200	1/500
Figures running across camera	1/500	1/1250
Cars, 10 m.p.h. towards camera	1/100	1/250
Cars, 10 m.p.h. across, or 30 m.p.h. towards camera	1/300 or faster.	1/750 or faster.
For faster cars at any distance	Follow in finder and use highest speed.	
Cyclists, or trotting horses, towards camera	1/150	1/500
Cyclists, or trotting horses, across camera	1/500	1/1250
Sporting events: races, jumps, hurdles, etc.	Highest available speed	
Swimmers: bathing scenes with movement	1/75	1/200
Divers	1/500	1/1250
Yachts, steamers, etc., at 50 ft. or over	1/100	
Speed-boats, towards camera at 50 ft. or over	1/150	
Speed-boats, across camera at 50 ft. or over	1/500	

Since much depends on whether the object is moving towards or across the lens and on the independent movement of parts (e.g., legs and arms) in objects that do not move as a whole as does a motor car, the figures given in the above table are at best approximate.

The instruction in the above table to " Follow in finder and use highest speed " indicates another line of approach to the photography of fast-moving objects. Where the object moves as a whole, it is theoretically possible to keep the image completely stationary on the film by so swinging the camera as to keep the object always in the same position in the finder. In practice it is difficult to do this with real precision, but it is easy to reduce the image-movement so far that sharp pictures of a racing car at 100 m.p.h. can be taken with exposures of 1/200th to 1/300th second, though shorter exposures may be given if the shutter and the prevailing light permit. Photographs taken in this way show the object sharply, but the background is blurred owing to the movement of the camera. This may or may not be objectionable; often it is of great assistance in suggesting the rapid movement of the object.

(For distortion caused by focal-plane shutters, see SHUTTER.)

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M.Q. An abbreviation used for metol-quinol or metol-hydroquinone developer. (See DEVELOPMENT, also METOL and HYDROQUINONE.)

M-Synchronization. Synchronization suitable for M-class flashbulbs, which reach their peak output of light about 20 milliseconds after the firing contacts are closed. In an M-synchronized shutter there is a clockwork which releases the shutter blades (which take about 1 to 2 ms. to open) some 15 ms. after the shutter-release has been depressed and the firing contact made. (See *Synchronization* under FLASHGUN.)

Multigrade. An enlarging paper introduced by Ilford, Ltd. coated with a mixture of a soft blue-sensitive emulsion and a hard yellow-sensitive emulsion. By suitable choice of a blue or yellow filter over the printing light or the lens of the enlarger, this paper may be made to give a print of any contrast from very hard to very soft. Alternatively, the exposure may be suitably divided, part being given by blue and part by yellow light, the relative times given through the two filters controlling the contrast.

Multiplying Camera. A camera for making a number of small negatives on one plate. (See REPEATING BACK and POLYPOSE.)

Muriatic Acid and **Muriates.** Muriatic acid is an old name for hydrochloric acid, and chlorides were called muriates.

Mydochrome. Trade name of colour developing agent manufactured by May & Baker. (See COLOUR DEVELOPING AGENTS.)

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N

Narrow Angle. See ANGLE OF VIEW and WIDE ANGLE.

Nature Photography. A very important branch of photography which has accomplished a great deal towards awakening a wider and a more intelligent interest in natural history. Under this heading may be placed the photographing of birds, animals, fishes, insects, plants, and geological subjects.

The subjects to be photographed will largely determine the choice of camera. Where it is to be used in the hand for subjects not likely to wait while a tripod is erected, a reflex or miniature camera is generally preferred, selecting those types which can be fitted with long-focus or telephoto lenses. These enable the photographer to take his stance at a greater distance from the subject, thereby reducing the risk of alarming the animal, bird, or reptile, and reducing also any danger there may be for the operator or his apparatus. The lens used should be of large aperture, thus enabling high shutter speeds to be used for moving creatures, and making it possible also to give snapshot exposures in dark and shaded places. Unless grain is feared, the fastest sensitive material should be chosen for the same reasons.

For the photography of small stationary objects such as flowers, plants, geological formations or specimens, or insects that have been caught and taken home to photograph, a hand-and-stand camera with ample extension is more suitable. A camera of this type is convenient also for bird photography from a hide, or for any work where a tripod can be used and focusing done on some fixed point such as the mouth of a rabbit's burrow or a bird's nest. As such a camera usually has a diaphragm shutter, which has lighter releases than focal-plane shutters, it is specially suited for use with a remote-control release.

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The following hints on bird photography by Oliver G. Pike should be noted:—

When stalking a bird, do not walk straight towards it, but walk in a zig-zag fashion, stopping every few steps.

If photographing a bird at a nest, always try to be hidden with the camera.

Never keep a bird off its eggs more than two hours. If it does not return in that time there is something wrong with the photographer's method of hiding.

If it is not possible to hide with the camera, use string, or an electric release for the shutter. When using the former, attach the string to the shutter release with a piece of thin cotton. This will prevent the camera rocking during exposure, for if the string is pulled too hard the cotton breaks.

Do not try to make slow exposures with a telephoto lens while holding the camera in the hand. A solid support must in such cases be used.

Remember that it is always better to obtain a small and sharp image of the bird on the plate than a large and badly focused one. It is always better to use backed plates when photographing sea birds.

A very rigid tripod should be used with a large top. It is a good plan to also have a small tripod, 18 in. high. This is very useful when working in a tent or under shelter.
(See also Zoo Photography.)

Negative is the term applied to a photographic image in which the lights and shades are reversed. Negatives can be made on sensitised plates, films, or paper, by direct action of light in the camera, or by printing, in a frame or through an enlarger, from a positive. (See Plates, Films, Development.)

Negative Storing. For plates, paper negative-bags or envelopes are both convenient and compact, and allow of any desired data being written upon them. A complete file is easily made by pasting a contact-print on the front of each bag and writing data on the back. Stored in boxes, or drawers of card-index type, they are both safe and easily located.

Films can be kept in rolls if the enlarger is fitted with a carrier allowing the film to be fed through in a continuous strip. Frequent rolling and unrolling is, however, a prolific

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source of scratches, and it is safer to keep the negatives in transparent paper envelopes that allow the negatives to be seen without withdrawing them. In the larger sizes one negative per envelope is convenient; in the smaller sizes a strip short enough to be stored flat but long enough to handle in comfort is preferable. Envelopes, separately or in album or wallet form, can be obtained commercially.

Experience has shown that bags or wallets of transparent plastic are liable to produce glazed patches on the negatives after some months of storage. Waxed paper, however, is safe.

Newton's Rings. An interference effect arising from close, but not quite perfect, contact between two surfaces. Generally met with photographically when enlarging from a film; the glass plate holding the film flat may make perfect contact at one point, and imperfect contact round it. The point is then surrounded by irregular concentric rings of colour, which show on the enlargement as rings alternately lighter and darker than the rest of the print. The plain celluloid back of 35-mm. cine film is particularly prone to give rise to this trouble. A mask between glass and film to prevent actual contact is the only cure, short of smearing the film with glycerine to ensure absence of air between the two. Newton's rings are also sometimes seen in projecting a celluloid transparency bound between glasses; in this case the rings are, of course, seen coloured.

In the manufacture of lenses, or the preparation of optically flat surfaces, the presence or absence of interference-effects of the same type as Newton's rings may be used as a test to determine whether the surface has been ground to the required form.

Niepceotype. (1) A term sometimes applied to the bitumen process, invented by J. N. Niépce about 1816, and the first method by which a camera picture was obtained. (2) The albumen process (*q.v.*) on glass due, as far as its main features are concerned, to Niépce de St. Victor.

Night Photography. See ARTIFICIAL LIGHT, PHOTOGRAPHY BY.

Nitraphot. An electric lamp specially intended for studio work. The standard type consumes 500 watts, and gives light about equivalent to a 1000-watt lamp of normal type. Average life, 100 hours. It is internally frosted ("pearl"),

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smaller in dimensions than a standard 500-watt lamp, and is fitted with E.S. cap. See also OVER-RUN LAMPS.

Nitrate Film. Term applied to 35-mm. film coated on a base of cellulose nitrate instead of the cellulose acetate normally used for miniature camera work. The nitrate base is highly inflammable, whereas the acetate base is not. As the nitrate base is still widely used for professional cinematography, any nitrate film offered to amateurs is usually derived from the " short ends " of the cine studios.

Nitric Acid (Fr., *Acide nitrique ;* Ger., *Salpetersäure*). $HNO_3 = 63$. Synonym: Aquafortis. Prepared by distillation from Chili saltpetre (sodium nitrate) and sulphuric acid. A heavy liquid fuming in the air. It is extremely corrosive —the antidote being any alkaline earthy carbonate, as chalk, lime, magnesia.

Nitro-Hydrochloric Acid. See AQUA REGIA.

Nodes, Nodal Points. These are formally defined in the article LENS. Their practical importance lies in the fact that, so long as we measure the distance from image or object on one side of the lens to one node, and of object or image on the other side to the other node, the distances precisely fit the simple lens-formulæ derived from the case of a lens so thin that it does not matter to what part of it measurements are made. All such distances given, or calculable from formulæ, in this book refer to measurements made from the appropriate node, not from the front or back surface of the lens, nor from any other fixed point—*e.g.*, the diaphragm. One or both nodes may in some cases lie right outside the lens ; in telephoto lenses this is almost always the case.

The node to which object-lens distances are measured is often called the *node of admission*, since it concerns light entering the lens ; the node from which lens-image distances are measured is similarly often called the *node of emission.* (See LENS.)

Non-Actinic Light. Light devoid of chemical—*i.e.*, photographic—action. No light is absolutely non-actinic, even with material not sensitised for colours other than blue, but the term is applied to light that can fall reasonably freely on the material in use without affecting it appreciably. (See LIGHT ; also DARK-ROOM and SAFELIGHT.)

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Obernetter's Process, or Lichtkupferdruck. A mechanical printing process giving extremely pleasing results. The silver image of a gelatine positive is converted into silver chloride, and the film is then stripped and applied to the surface of a copper plate, and, under the influence of an electric current, the silver chloride is decomposed, and the chlorine unites with the copper and etches it to a greater or less degree, according to the depth of deposit of silver chloride. The result is a grained intaglio plate of extreme delicacy and beauty, which is inked and printed from as is any other intaglio plate. (See PHOTO-MECHANICAL PRINTING PROCESSES.)

Objective. A term sometimes applied to the image-forming lens of an optical instrument, as, for example, the lens used with the photographic camera or enlarger. (See LENS.)

Oil Paintings, to Copy. See COPYING.

Oil-Pigment Process. This process is a method of making photographs in oil pigments on a gelatine base, in which the image has been produced by the action of light. The procedure is as follows :—

Paper covered with a thin coating of gelatine, such as the double transfer paper used in the carbon process, is sensitised by floating on a 5 per cent. solution of potassium bichromate.

Alternatively, the solution may be brushed over the gelatine surface with a Blanchard's brush (*q.v.*).

The entire surface is rapidly covered in broad, even strokes, and an even amount of solution is taken up and spread, and the operation repeated in the opposite direction. The paper is then put away in the dark, and when quite dry is ready for printing. With a spirit sensitiser (see CARBON), the paper dries in a very few minutes.

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The bichromatised paper, when dry, is exposed under the negative to daylight. A strong negative is required. The exact time for printing is determined by an inspection of the surface of the bichromatised paper, care being taken not to expose it unnecessarily to light.

The image is fully printed when detail can be clearly seen in the highest light. The print is now removed from the printing frame and washed in plain water until all trace of the yellow bichromate stain has disappeared, when it is completely insensitive again.

The print is now placed on a pad of wet blotting-paper, and inked up exactly as described under BROMOIL.

Oil Reinforcement. Process of "finishing" a print (usually bromide) by reinforcing or modifying the image with oil pigment. (See *Retouching and Finishing Bromides*, under BROMIDE PAPER.)

Oil-Transfer Process. A method of transferring the pigmented image produced in an oil print (*q.v.*) to another paper support by means of pressure, the process thus being analogous to collotype. (See BROMOIL TRANSFER.)

Oleobrom Process. A modification of the bromoil process (*q.v.*). The paper, which was a specially prepared bromide paper, was bleached in the ordinary way, surface dried, inked all over by means of a roller, and then the image developed with the inked roller under water, and finally cleaned up also by special composite rollers.

Opacity. In photography, the light-stopping power of an image. A deposit of silver that stops seven-eighths, and passes one-eighth, of the light incident upon it has an opacity of 8. In this more technical sense, opacity and density must be sharply distinguished; the latter is the logarithm of the former. (See SENSITOMETRY and DENSITY.)

Opal and Opalotype. Opals, which were opal glass (*q.v.*) coated with emulsion, were at one time often used for producing Opalotype transparencies. A similar result may be obtained by transfer (see TRANSFEROTYPE, CARBON PROCESS).

Opal Glass. Glass so treated as to appear like porcelain, but remaining highly translucent. Chiefly used in photography as a diffusing screen for enlargers. (See FLASHED OPAL.)

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Opal Lamp. Electric bulb of opal glass (*q.v.*). Used in most modern enlargers as a source of diffused light. A "pearl" (internally frosted) bulb gives very much less diffusion.

Open Flash. Method of flashing used with a shutter having no synchronizing contacts. The shutter is opened on "B", the flash fired, and the shutter immediately closed again.

Optical Contact. See CONTACT, OPTICAL.

Optical Flats. Pieces of glass, the surfaces of which are both plane and parallel to a very high standard of exactitude. Their use in photography is practically confined to light filters. Unless the coloured glass of which the filter is made, or the two pieces of clear glass between which a gelatine filter is cemented, have truly flat surfaces precisely parallel with one another, the definition of the photograph may be slightly degraded. For all normal use picked samples of "patent plate" glass are sufficiently satisfactory, but for exacting work, especially with lenses of long focus and wide aperture, a filter in optical flats is very desirable.

Optical Glass. See GLASS.

Optical Lantern. See PROJECTOR.

Optical Sensitising. The use of a dye to confer upon a photographic emulsion sensitivity to light of wavelengths to which the silver halides are insensitive without such aid. A full account of the theory and practice of optical sensitising will be found in Chapters 10, 11, and 12 of *The Theory of the Photographic Process*, by C. E. K. Mees.

Optics. That branch of science relating to the nature and laws of light.

Orange Light. In referring to light filters or dark-room safelights, this term implies light from which blue and blue-green are absent, so giving the sensation of orange. Such light is "safe" for slow non-colour-sensitive material such as bromide paper. In referring to the spectrum, or to the sensitivity of a film to colours, orange light means light of wavelength round about 6500 A.U. (See LIGHT.)

Ordinary Emulsion. An emulsion not specially sensitized to colour, and consequently affected by blue light only.

Orthochromatic Emulsions. Synonym, Isochromatic. Terms applied to emulsions, whether on plates or films, that have been rendered sensitive to green and yellow light. (See COLOUR-SENSITIVE EMULSIONS.)

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Orthophenylenediamine. 1-2-diaminobenzene, $C_6H_4(NH_2)_2 = 108$. Fine-grain developing agent, similar in properties to paraphenylenediamine, compared with which it oxidises less rapidly in air and is less likely to attack the skin. It is also more expensive, and possibly for that reason has never been widely used by the amateur, though it is a constituent of a few proprietary fine-grain developers.

Ortol. Mixture of hydroquinone and methylorthoaminophenol sulphate, a close relation of metol. Developing agent obsolete since 1914. (See DEVELOPMENT.)

Out-of-Date Films. Term applied to films that have been kept beyond the expiry date marked on the carton. This date indicates the expiry of the period during which the manufacturers are prepared to guarantee that the film, if reasonably stored, will remain in substantially fresh condition. Frequently they remain in perfectly usable condition for many months past this date, though they may lose a little speed.

The effect of age is more serious with colour films, for there can be no certainty that the three emulsions have all suffered the same loss of speed. An old film, besides being slow, may have changed in colour balance. When using colour negative film any such change, if not too great, can be corrected by choice of filter in printing, but loss of balance in reversal film necessarily gives a transparency with an incorrect colour bias.

Over-Exposure. An over-exposed negative is one to which so long an exposure has been given that the high lights are flattened and lacking in contrast. (See SENSITOMETRY and EXPOSURE.) An over-exposed print or lantern-slide is one that, having received correct development, is too dark and heavy. In both negatives and prints the effect of over-exposure can often be lessened by reduction (of density), (*q.v.*).

In a colour transparency, over-exposure is shown by burnt-out highlights and, usually, a general thinness and lack of density.

Over-Run Lamps. Any electric lamp used on a voltage higher than that with which it would last out the normal life of 1000 hours is said to be over-run. Lamps of the photo-flood type giving about as much light as a normal 800-watt lamp, but consuming only 275 watts, are heavily over-run; their life is about 2 hours. The "nitraphot" or studio lamp, giving as much light as a normal bulb of double its consumption, is slightly over-run, and has a life of about 100 hours. Ordinary electric bulbs may be over-run; their life is greatly reduced

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and their consumption of power increased, but the light-output rises steeply and efficiency is considerably increased.

The following table shows the performance of a lamp run at various voltages, that for which the lamp is rated being taken as unity. The figures are amply accurate as a guide to photographic work, but are not precise; they will vary a little with the rated power and voltage of the lamp.

Relative Voltage	Life (hours)	Relative Watts.	Efficiency lumens per watt.	Relative Light Output	Colour Temp.
0·9	3700	0·83	8·0	0·67	2650°A
1·0	1300	1·00	10	1·0	2750°A
1·1	600	1·15	12	1·4	2840°A
1·2	250	1·35	14·5	2·0	2920°A
1·3	130	1·52	17	2·5	3000°A
1·4	65	1·72	19·5	3·3	3080°A
1·5	32	1·93	22·5	4·3	3150°A
1·6	18	2·15	25·5	5·3	3220°A
1·7	10	2·4	29·5	6·9	3290°A
1·8	6	2·6	32·5	8·4	3350°A
1·9	4	2·8	36·5	10	3410°A
2·0	2·3	3·1	41	12	3475°A
2·1	1·5	3·3	45	14·5	3530°A
2·2	1·0	3·5	49	17	3580°A

For reasons of space, column-headings are perhaps a little cryptic, but an example will make things clear. Suppose a 200-volt 100-watt. lamp is run on 240-volt mains. Then the voltage is 1·2 times that for which the lamp is rated. The expectation of life is about 250 hours, and the power consumed will be 1·35 times the rated wattage—*i.e.*, 135 watts. The efficiency will rise from 10 to 14½ lumens per watt., and this, taken in conjunction with the rise in power-consumption, will increase the light-output to just double that which the lamp would give if used on its rated voltage. The colour-temperature (*q.v.*) will rise to about 2920° A.

It is quite safe to over-run ordinary lamps a little without taking special precautions, but if heavy over-running is to be attempted a closely calculated fuse, rated to blow at very little more than the expected consumption of the lamp, should be inserted in the circuit. Without the fuse, there is always the possibility that if the lamp burns out it may explode as it does so. See FUSE.

See also PHOTOFLOOD and NITRAPHOT.

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Oxidising Agent. Chemical substance capable of yielding up oxygen, or its equivalent, to other substances. Potassium permanganate and other substances used for bleaching or "reducing" negatives or prints are typical of this class of substance. (See REDUCING AGENT, and REDUCER.)

Oxygen. O = 16. Gaseous element making up about one-fifth of the atmosphere, the bulk of the rest being nitrogen. It is the most abundant element known, forming about half the weight of the entire earth. Combustion consists, in all usual cases, of combination with oxygen, and it is the gas absorbed by animals during respiration. A developing solution will soon absorb oxygen if exposed to the atmosphere, and will lose its ability to develop. Other photographic chemicals, including particularly sodium sulphite and sodium sulphide, must also be protected from atmospheric oxygen. (See ATMOSPHERIC ACTION.)

Ozobrome. This process, due to Thomas Manly, is a method of making carbon prints from bromide prints or enlargements without the action of light. The process in an improved form is now known as Carbro (*q.v.*).

Ozotype. A process patented by Thomas Manly, in which a print is made on gelatine-coated paper sensitised with a bichromate. A pigment image is developed after squeegeeing in contact with carbon tissue that has been previously soaked in an acidified solution of hydroquinone or ferrous sulphate. The Ozobrome process (*q.v.*) was developed from the earlier Ozotype.

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P

Palladium : Palladiotype. Palladium is a metallic element sometimes found native in the nearly pure state, and frequently with platinum, which it much resembles. It has been recommended for toning transparencies and enamels, but its use is limited. Palladiotype is a printing process similar to platinotype, but with palladium in place of platinum. Full details for working palladiotype are given under PLATINOTYPE (*q.v.*).

Panchromatic Emulsions. Plates and films sensitised for all visible colours, including red, are termed panchromatic to distinguish them from those which have been sensitised for green and yellow only (Orthochromatic Emulsions, *q.v.*). See COLOUR-SENSITIVE EMULSIONS.

Panel. Commercial name for a photograph of size about 4 by 8½ in. (See SIZES, PHOTOGRAPHIC.) Also applied to any photograph of long, narrow shape.

Panning. Term applied by the cinematographer to a slow traversing movement of the camera, as a result of which the view moves sideways across the screen when the picture is projected. By this means a wide space of country can be surveyed.

The still photographer uses the same movement of the camera, and calls it by the same name, when he follows a moving object in his finder to enable him to get a sharp picture of it with a lower shutter speed than would normally be required. (See MOVING OBJECTS.)

Panoramic Camera. A camera taking long and narrow pictures, the angle of view corresponding to the greater dimension of the negatives being greater than can be included by a lens. The film is bent in a curve, and during the exposure

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the lens rotates about an axis passing through the node of emission at right-angles to the line of sight, in order to sweep out the entire field of view. Behind the lens is a tube terminating in a narrow opening the length of the narrow way of the film; this tube rotates with the lens, exposing the film piecemeal.

Panoramic Head. A tripod-head capable of revolving on a vertical axis, and graduated, in degrees or otherwise, to show how far to turn the camera after each exposure to ensure that successive views will overlap enough to enable them to join correctly to form a panorama (see PANORAMIC VIEWS). To join prints from negatives made with a panoramic head it is necessary to trim so that the amount cut away from each end of each print is the same.

Panoramic Views. If a special panoramic camera (*q.v.*) is not available, an ordinary camera may be used, a series of pictures being taken in succession from a fixed point and subsequently combined. It is preferable to mount the camera on a tripod, if possible with a panoramic head (*q.v.*), so as to ensure that the axis of the lens is strictly horizontal.

As cylindrical perspective (required for a panorama) is not the same as plane perspective (as given by a camera), adjacent views will only match accurately if the line joining the lens of the camera to the part of the view at which the junction is to be made makes equal angles with the two successive directions of the axis of the lens.

After trimming the edges to be joined, the prints may be mounted as follows. First, place them face outwards on a window so that the images can be seen through the paper, and make registration lines on the edges of each print. Then soak them till the paper is fully expanded, and squeegee them down in register on a glass coated with collodion (see GLAZING PRINTS). Check registration from the front. Before the prints are dry, paste over their backs a piece of stout paper that has been well wetted, using a thick paste; the contraction of this will prevent the prints from separating as they in turn contract on drying. When the whole is dry, strip from the glass, trim round the four outer edges, and mount the assembly as desired.

It should be noted that no panoramic picture can ever be seen in correct perspective if it is presented on a plane; if taken with a panoramic camera the print should be bent round in a circle, or part of a circle, the radius of which is equal to the focal length of the lens. (Or to m times this, if the prints have

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been made by an enlargement of m diameters.) For viewing it, the eye should be placed at the centre of the circle. The corresponding formation for a built-up print is closely similar, but the circle should strictly be replaced by a polygon, one side of which is formed by each separate print.

Paper Negatives. Negatives made on a paper base in place of glass or celluloid. Paper roll "films" are on the market, and special negative paper is made in all standard cut sizes. Exposure is normal, and development is done as for a bromide print, the density of a normal print being aimed at. Printing is by reflection, using a projector of episcopic pattern (see EPISCOPE) both for "contact" (same-size) prints and for enlargements. The sole advantage of the paper negative for direct work in the camera is its cheapness.

It is, however, in the production of enlarged negatives that the paper negative is of the greatest value. Besides cheapness, it offers lightness and lack of risk from breakage, but in particular it allows broad retouching to an extent hardly possible with any other type of negative. In addition, it enables the amateur to make use of the various daylight printing processes for the production of large pictures and exhibition prints. For this purpose, the paper negative requires to be much heavier than for printing by reflection; it must be judged, as it is to be printed, by transmitted light.

For making the enlarged negative a small transparency is of course needed. This is generally made by contact from the negative on a slow plate. This positive should reproduce all the delicate gradations of the original negative and in appearance it should be somewhat "flat."

The procedure in making the enlarged negative on paper is precisely the same as that followed in making a bromide enlargement. Thin, smooth, bromide paper may be employed, but special negative paper is obtainable from several makers.

In making the paper negative, correct density must be judged by transmitted light, making allowance for the thickness of the paper itself. Developer and fixing bath are exactly as for bromide paper.

If the grain of the paper is thought to be too obtrusive, or if it takes too long to print, the dry negative can be rendered more translucent by rubbing into the back with a pad of cotton-wool a solution of one part of Canada balsam in five parts of turpentine.

Another method is to heat paraffin wax or white beeswax

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in a shallow tin tray placed in a dish of boiling water. The paper negative is floated on the liquid wax, film side up. It is then removed, placed between blotting-paper, and ironed with a hot iron. Alternatively, two treatments with a brush dipped in Vaseline oil may be given at an hour's interval.

Before treating, by any process, the paper must be dried before the fire to drive out all trace of moisture, otherwise the wax or Canada balsam will be excluded from the moist fibres, so accentuating the grain of the paper.

Grain may be very greatly lessened in any paper negative or intermediate positive by exposing through the paper when making it; there is then included with the pictorial image an image, in negative, of the grain of the paper. On printing from this, the grain-image tends to nullify the grain which caused it. More accurate compensation for grain can be had by exposing the back of the paper to light without the intervention of a negative or positive. The length of this exposure must be adjusted, by previous trial on a test-strip, so that on development to finality the image exactly neutralises the grain. This exposure may be made before or after printing the photographic image, which is now done on the sensitive side of the paper, and not through the back.

The paper back of the negative offers endless opportunities for the correction of faulty tones or for the entire removal or alteration of any objectionable detail. This work can be accomplished by means of pencil or stump, and trial prints should be made at intervals to note progress. For retouching the negative is lightly held to a window by means of pieces of gummed paper at the edges.

If the entire negative is not rendered translucent, shadows can be darkened by rendering small portions translucent where necessary. The Canada-balsam treatment is best for this local work. If the greatest degree of control is desired, a paper positive may be made by enlargement from the original negative, retouched as required, and then printed by contact to give the final enlarged negative on which more pencil work may again be done. In this method all work involving darkening is done on the positive, that involving lightening of tones in the final print being done, as before, by darkening the negative.

In the absence of a large printing frame, two sheets of stout, clear glass a little longer than the negative may be used. A piece of smooth opaque paper is laid on one piece of glass, then the printing paper, face upwards. On this is

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laid the paper negative, face downwards, and finally the other piece of glass. If the exposure is to be brief, as in printing a bromide, chlorobromide, or gaslight paper, the weight of the top piece of glass will be enough to hold negative and paper in good contact. But if printing is to be done by daylight, as in making a carbon or P.O.P. print, the glasses should be held together by bull-dog clips or other convenient means. The improvised frame should not be touched until the print is fully exposed.

(See also ENLARGING.)

Papers, Photographic, Testing of. The chief characteristics of a printing paper that the user should know are speed and contrast. Measurement of absolute speed is beyond the range of the equipment of the ordinary amateur; all he can do is to find the relative speeds of the different papers he uses, or of different batches of paper nominally the same. This can be done by comparing the times of exposure necessary to produce either the first visible darkening on development, or a tone just distinguishable from full black, when the two papers are exposed at the same distance from a constant light. In either case he should have a standard tint, just off white or just off black as preferred, against which to determine the exact value of the exposure-times.

As two papers may not have the same contrast-range, comparisons of speeds made by these two methods may not indicate the same ratio of speeds. Either method of comparing speeds will give the desired information, however, provided it is supplemented by an independent determination of the contrast-range of the paper. This can be carried out by giving a series of exposures test-strip fashion, and observing the ratio of the times necessary to give the two standard tints just mentioned.

If a nearly full black requires six times the exposure needed to give a just-visible darkening, the contrast-range of the paper is six. If, however, the darker tone requires twenty times the exposure of the lightest, the contrast-range is twenty. For a full-range print with the former paper, the opacity-ratio between high lights and shadows in the negative would only need to be six, whereas with the latter paper it would need to be twenty. The former paper, requiring the weaker negative, is of the contrasty variety; the latter is a soft paper.

Besides determining relative speeds, and the absolute value of the contrast, the tests that an amateur can apply to printing paper are few and unimportant. About the only other useful

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test is one for condition. An old paper, or one that has been improperly stored, is liable to give " mealy " prints with foggy, mottled edges. This shows up most noticeably on prolonged development ; if a print, made with a white margin to show up fog, still has clean fog-free whites after development for double the time necessary for apparent full development, the paper may be relied upon as being in good condition. Even though speed and contrast may have changed, it is still capable of giving prints of perfect quality from a negative of suitable contrast.

Parabolic Mirror. A mirror the cross-section of which is a parabola. Such a mirror has the property that a point source of light, placed at the focus of the parabola, is reflected as an accurately parallel beam.

Parallax. Change in the apparent relative position of two objects when seen from different points of view. In scientific work generally, applied to such matters as the reading of the position of a pointer moving over a scale. If viewed at an angle, the pointer may appear to coincide with a scale-marking to one side of that against which it actually lies. Parallax-error of this type cannot arise if the pointer is in actual contact with the scale, and can be avoided, even if the pointer is some way from the scale, by choosing a viewpoint such that the line joining the eye to the pointer is exactly at right-angles to the surface of the scale. The focusing-scale of a camera using rack-and-pinion focusing often needs to be read with care if parallax-error is to be avoided.

In addition to the above general meaning, the term " parallax " has a special photographic meaning. It is applied to indicate the difference between the view seen in a finder and that which will actually be photographed by the lens. As it is only in a single-lens reflex that the lens used for taking the picture is also used for viewing, parallax-errors may arise with cameras of any other type.

If the axis of the finder is parallel to that of the lens, and is set four inches higher, the finder will include four inches more at the top of the subject, and four inches less at at the base, than the negative will show. The four inches in question are, of course, measured on the subject, not on the image. In taking a large object at a distance, (a mountain or a cathedral, for example) the error is completely negligible, but it may become important in taking a close-up portrait. If the sitter's hat is

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shown on the finder as just included, the negative may show nothing of it above the brim.

Parallax-correction is fitted to some cameras, the view-finder tilting down, automatically or otherwise, for near objects in such a way that the axes of the finder and of the lens intersect in the plane of the subject. By this means the boundaries of the picture in the finder are made to correspond with those of the camera itself. With bright-line finders, the plate carrying the frame marking out the limits of the field of view is often made to move appropriately as the lens is focused.

A less ambitious form of correction sometimes used is to restrict the field of view of the finder so that it does not include anything that will not also be included in the negative, so long as the distance of the subject lies within the normal focusing-range of the camera. Such a finder does not at any time show the full field of view, but the discrepancy is not large.

None of these methods of correction can prevent parallax in its more general sense ; even if the field of view of the finder is correct for objects in the plane focused upon, these objects must always be seen against different parts of the background so long as the viewpoints of camera and of finder are not the same.

Parallax Stereogram. The parallax stereogram of F. E. Ives is a positive transparency which consists of narrow stripes alternately derived from the two halves of a stereogram ; and in front of this composite positive, but not quite in contact, there is fixed a line screen which is so adjusted that each eye sees its appropriate set of stripes.

Paraminophenol 1—4 $(NH_2)C_6H_4(OH) = 109$. Often written para-aminophenol or *p*-aminophenol. Sometimes called para-midophenol. A white or greyish powder, darkening on exposure to air, and best stored in a bottle sealed with a waxed-in cork. It is a developing agent of moderate activity, Watkins factor 12 to 30 according to formula used. Particularly free from tendency to fog, even at high temperatures ; in consequence often preferred for tropical development. Does not give aerial fog, and so is particularly valuable for developing films by the see-saw or drum method. Solubility in plain water, about 1·2 per cent. ; less (about 0·25 per cent.) in 10 per cent. sulphite solutions or in solutions of sodium carbonate.

With caustic alkalies paraminophenol makes a very highly

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soluble aminophenolate (*e.g.*, $(NH_2)C_6H_4(ONa)$), enabling an extremely concentrated developer to be prepared. (See DEVELOPMENT.) Rodinal (*q.v.*), Azol, and Certinal are preparations of this type.

Those who suffer from metol poisoning can in nearly all cases use paraminophenol, which has somewhat similar characteristics, with complete impunity.

Paraminophenol is often sold in the form of the hydrochloride (M.W. = 145·5), which is much less easily oxidised by air. Care should be taken not to use the hydrochloride unless the formula definitely specifies it, particularly when making up a concentrated developer. When caustic soda is added to the hydrochloride, common salt is formed, and the low solubility of this limits the concentration of the developing solution. In other cases, note that four parts of the hydrochloride have the same developing activity as three parts of paraminophenol base. In all cases, substitution of the hydrochloride for the pure base will necessitate the addition of a suitable additional amount of alkali (0·275 gm. of caustic soda, or 0·365 gm. of sodium carbonate, per gram of paraminophenol hydrochloride) to neutralize the hydrochloric acid contained in it. (See DEVELOPMENT and TROPICAL WORK.)

Paraphenylenediamine. Paradiaminobenzene $NH_2C_6H_4NH_2$ = 108. Is usually sold in Britain as the free base.

Known in U.S.A. as P.P.D. Crystalline plates, colourless if pure, but a very small amount of impurity gives rise to quite a deep colour. Often met with as a pinkish powder, and is soluble in cold water to the extent of about 1 per cent. A developing agent of low activity, once much used in fine-grain development (*q.v.*), but can be considerably activated by the addition of other developing agents—metol, glycin, and pyrocatechin have all been used (see MERITOL). With a caustic alkali, paraphenylene diamine forms a developer of full normal activity, and no longer gives fine grain.

The *dry* substance, and its salts, may cause skin eruptions in sensitive persons. Solutions are harmless unless allowed to dry on the skin. If spilt, developers containing paraphenylenediamine cause intense stains.

When combined with pyrocatechin forms Meritol (*q.v.*).

Paraxial. An optical term meaning "near the axis." The paraxial region of a lens is thus the central portion; a paraxial ray is one that lies close to the axis throughout its path.

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Passe-Partout. Term applied to a method of mounting or framing in which the print, mounted or otherwise, is sandwiched between a back-board of card or wood and a sheet of glass, the whole being held together and rendered dustproof by being bound round the edges by strips of gummed cloth or paper. Rings or loops are generally attached to the back-board so that the finished picture can be hung up.

A piece of glass is taken of exactly the same size as the outer dimensions of the mounted photograph to be framed. (The usual plan is to trim the mounted print by the glass.) A piece of stout millboard or thin wood, also of the same size, is taken for the back-board. Strips of thin, tough paper of the desired colour, and cut to the length of each side of the glass (four in all), are prepared. These should be about ¾ in. to 1 in. wide, and are stuck on with strong paste. The best plan is to apply the strips to the glass first so that about ¼ in. of the length of each piece overlaps the glass. These four binding strips can now be allowed to dry on the glass, or the process can be continued at once. Turn the glass over, and remove all dust, finger marks, etc., place the print face downwards on the glass, and the backing board on top. (In the latter a couple of rings should be fixed by means of tapes or pieces of thin wire running through small holes. These rings are needed for hanging up the *passe-partout* later, and should be placed near the top end.)

The projecting edges of the binding strips are now well pasted and turned over on to the back-board, taking care that the edges of the glass and back make a neat and straight line all round. The whole can then be put under slight pressure until quite dry, when the entire picture can be hung up by the rings at back.

Passport Photographs. In applying for a passport, two copies of a recent photograph must be sent. They must be taken full face, without a hat, and must be unmounted; paper with a waterproof back must not be used, as one copy has to be pasted into the passport. The size must not be more than $2\frac{1}{2} \times 2$ in. nor less than $2 \times 1\frac{1}{2}$ in.

Paste. See MOUNTANT.

Patents. The photographic inventor who wishes to act for himself should apply, personally or by letter, at the Patent Office (25, Southampton Buildings, Chancery Lane, London) for a copy of "Instructions to Applicants for Patents."

Owing to the present complication of the Patent Law, it is

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wiser to engage a Patent Agent, whose charges may be as low as £5 or £6, but searches, official requisitions for complex drawings, and possible hearings before the Examiners or Comptroller, may involve very much heavier expenses.

The total cost in fees for a patent available for four years is £11, after which yearly fees ranging from £5 to £20 are payable, otherwise the patent lapses. If the would-be patentee wishes to incur the minimum expense at the outset, he can, for £1, file a provisional application and he then has 12 months in which to file his complete specification.

Pearl Lamp. Electric bulb the glass of which is internally frosted to provide a certain amount of diffusion with minimum loss of light. For use in an enlarger the diffusion is generally insufficient, and an opal lamp (*q.v.*) is used in place of it.

Pencil of Light. A term applied to a narrow beam of light proceeding from a source. When the source is near, the pencil is divergent; when very distant, the pencil may be considered parallel. A pencil which grows less in diameter as it proceeds is said to be convergent.

Pendulum. For timing the exposures given to prints or enlargements, or for keeping track of the time when developing films in complete darkness, a simple pendulum is often used. This may consist of a light thread or wire with a weight at one end, or of a thin rod, again with a weight at the bottom end, rocking on a knife-edge bearing. If all the weight is considered concentrated in the bob, the string being by comparison weightless, then the periodic time of oscillation is equal to $2\pi\sqrt{\frac{l}{g}}$, where g is the acceleration due to gravity and l is the length of the pendulum, measured from the point of support to the centre of gravity of the bob. If l is measured in inches, the time of one oscillation is $0{\cdot}320\sqrt{l}$ seconds; if in centimetres, it is $0{\cdot}201\sqrt{l}$ seconds. If $l = 100$ cm., so that $\sqrt{l} = 10$, the time of one complete oscillation is thus 2·01 seconds.

Note that most people would say this pendulum was "beating seconds." The periodic time of 2 seconds given by the formula is counted from extreme left back to extreme left; each individual swing, from left to right or from right to left, therefore occupies *one* second.

A pendulum only keeps absolutely perfect time when its swings are either constant in amplitude (as in a clock) or, if allowed to vary in amplitude, are kept at all times very

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small. However, if the total swing of the bob (from extreme left to extreme right) is not allowed to exceed three-quarters of the length of the pendulum, the widest swing will not take more than one per cent. longer than the smallest. (See Toft and McKay, *Practical Mathematics*, pp. 500 et seq.)

See also TIMER and DARK-ROOM CLOCK.

Pentaprism. A prism of pentagonal cross-section having the property of reversing, along the direction of its axis, any image seen through it. Used as a viewer for reflex cameras; if the base of the prism is placed on the focusing screen of a reflex camera so that its axis runs at right-angles to that of the lens, then on looking into the prism the image, normally reversed from right to left, is seen correctly oriented. If the camera, with the pentaprism still attached, is turned on its side, so that the image on the screen is upside-down, the image seen through the pentaprism is inverted, and again is correctly oriented.

Known sometimes as a roof-prism.

Peppertype. A variety of the powder process (*q.v.*), by which a sensitive coating may be applied to almost any surface and an image developed by means of powder in nearly any colour or material:—

A. White pepper . . . . . 4 parts
Benzene . . . . . 10 parts

B. 5 per cent. solution of gum dammar in benzene.

C. Solution of indiarubber in benzene (fairly thick bicycle cement will do).

For use, take of A, 10 parts; B, 1 part; C, 1 part; filter, and coat any hard-glazed surface, as glass, opal, or hard-sized white paper. Expose under a transparency in direct sunlight and then dust over with any litho dry colour or powdered metals, as gold, silver, bronze, etc. A final brushing with a soft brush completes the process.

Percentage Solutions. See WEIGHTS AND MEASURES.

Periodicals. Weekly or monthly photographic journals are published in nearly every country of the world. The list below includes the chief journals printed in the English language.

British

Amateur Cine World (*w*): 46, Chancery Lane, London, W.C.2.

Amateur Film Maker (*2m*): 8, West Street, Epsom, Surrey.

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Periodicals

British (continued)

Amateur Photographer (*w*):	Dorset House, Stamford Street, London, S.E.1.
British Journal of Photography (*w*):	24, Wellington Street, Strand, London, W.C.2.
Camera Club Journal (*m*):	23, Manchester Square, London, W.1.
Cameras (*w*):	Bugle House, Noel Street, London, W.1.
Canadian Photography (2*m*):	750a, Yonge Street, Toronto, Ontario, Canada.
Colour Photography (2*m*):	46-47, Chancery Lane, London, W.C.2.
Good Photography (*m*):	324, High Holborn, London, W.C.1.
I.B.P. Record (*m*):	38, Bedford Square, London, W.C.1.
Image (4*m*):	18, Maids Causeway, Cambridge.
International Photo Contest (*m*):	Liverpolitan House, Claughton Road, Birkenhead, Cheshire.
Journal of Photographic Science (2*m*):	16, Princes Gate, London, S.W.7.
Leica Fotografie (2*m*):	93, Copse Hill, London, S.W.20.
Modern Camera Magazine (*m*):	9, Cavendish Square, London, W.1.
Perspective (*q*):	31, Fitzroy Square, London, W.1.
Photographic Abstracts (*q*):	16, Princes Gate, London, S.W.7.
Photographic Journal (*m*):	16, Princes Gate, London, S.W.7.
Photographic Retailer (*m*):	46, Bloomsbury Street, London, W.C.1.
Photography (*m*):	Vogue House, Hanover Square, London, W.1.
Photoguide Magazine (*m*):	31, Fitzroy Square, London, W.1.
Photo News (*w*):	114-115, Holborn, London, E.C.1.
Photo Trade World (*m*):	46, Chancery Lane, London, W.C.2.

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British (continued)	
Practical Photography (*m*):	Norfolk House, High Street, Guildford, Surrey.
South African Photography (*2m*):	Cor. W. Burger & Fountain Streets, Bloemfontein, South Africa.
Thirty-five Millimetre Photography (*m*):	46, Chancery Lane, London, W.C.2.
American	
Better Movie Making (*m*):	9, East 40th Street, New York 16, N.Y.
Camera News of W. Germany (*m*):	17, East 45th Street, New York 17, N.Y.
Home Movies (*m*):	672, South Lafayette Park Place, Los Angeles 57, Cal.
Leica Photography (*q*):	468, Park Avenue South, New York 16, N.Y.
Monthly Abstract Bulletin (*m*):	Eastman Kodak Co., Rochester, N.Y.
Modern Photography (*m*):	33, West 60th Street, New York 23, N.Y.
Popular Photography (*m*):	1, Park Avenue, New York 16, N.Y.
Professional Photographer (*m*):	552, Fifth Street, Lorain, Ohio.
P.S.A. Journal (*m*):	1822, Leland Avenue, Chicago 40, Ill.
U.S. Camera (*m*):	9, East 40th Street, New York 16, N.Y.
Other Countries	
Camera (*m*):	C. J. Bucher Ltd., Lucerne, Switzerland.
Ferrania (*6m*):	Corso Matteotti 12, Milano, Italy.
Japan Camera Times (*m*):	1-65, Jimbo-cho, Kanda, Chiyoda-ku, Tokyo, Japan.
Japan Camera Trade News (*m*):	429, Kamikitazawa 1, Setagaya-ku, Tokyo, Japan.

(*w*), (*m*), (*2m*), (*q*), (*4m*), and (*6m*), signify respectively weekly, monthly, every two months, quarterly, every 4 months and every 6 months.

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Permits to Photograph. Permits are not necessary, except in some cases for cameras used on a stand, in any of the open spaces under the control of the L.C.C. or in the Royal parks. For the use of a stand camera in parks and commons administered by the L.C.C., any permit must be obtained from the Chief Officer, Parks Department, London County Council, County Hall, Westminster, or from H.M. Office of Works, Storey's Gate, Westminster, in the case of the Royal parks.

The Royal parks are: Hyde Park, Kensington Gardens, Green Park, St. James' Park, Regent's Park, Greenwich Park, Richmond Park, Bushey Park, and Hampton Court Park and Gardens. Other open spaces in Greater London almost all fall under the control of the L.C.C.

In places where payment has to be made for admission, or where an official is in charge, enquiry concerning permits should be made on the spot. There are practically no open air places open to the public at which any objection is raised to the use of a hand camera, though in a few places a trifling fee is charged. Hand cameras and sub-standard cine cameras may be used without fee both indoors and out-of-doors at the Zoological Society's Gardens in Regent's Park, and at Whipsnade.

For photographing the interiors of cathedrals, historic buildings, museums, university colleges, and the like, permission is almost always needed and a fee is often charged. Application is best made in advance, by letter addressed to the appropriate official. A letter addressed to the Dean in the case of a cathedral, to the Curator or Director in the case of a museum or historic building, or to the Principal in the case of a university college, can be relied upon to reach the right person or department. In the case of ancient castles or monuments under the control of H.M. Office of Works, it is safest to apply to the address in the first paragraph above, or in Scotland to 122, George Street, Edinburgh, though permission to photograph can usually be obtained from the caretaker on the premises.

For permission to use a camera on railway premises, apply to the Traffic Manager at the London terminus of the Region concerned, or in the case of the London Region to the London Transport Executive, at their head office at 55, Broadway, Westminster, S.W.1.

Permission to use a camera at sports meetings, football matches, etc., should be asked from the secretary of the club concerned, enclosing stamped addressed envelope, while for

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the use of a camera at Royal processions and similar public functions application should be made to the police.

When abroad, guidance should always be asked of the nearest police station if there is the slightest doubt as to the propriety of using a camera. There may be laws, regulations, or conventions of good manners that may unknowingly be infringed if cameras are used with too careless a freedom.

Perspective. The representation upon a plane surface of the form of solid objects. Although the limitation is not theoretically necessary, the long tradition of painters and artists has established that the plane surface upon which the form of the solid objects is projected should be vertical. In consequence, a perspective-drawing made upon a non-vertical surface looks unfamiliar, and is usually said to be " out of drawing " or " distorted."

The fundamental laws of perspective can best be appreciated by considering a simple means of making a drawing in perfect perspective. In making such a drawing of a given object or scene, two things must be fixed ; the exact position from which the scene is to be viewed, and the scale of the drawing. A piece of card with a hole in it big enough to allow one eye to see in comfort may be fixed on a suitable stand ; this will determine the point of view. To fix the scale, a piece of glass of the size of the desired picture is mounted in a frame, and the whole is fixed, in a vertical plane, at such a distance from the eye-piece that the amount of view it is desired to include just fills the frame. The nearer this is brought to the eyepiece, the wider will be the angle of view.

With viewpoint and plane of perspective thus fixed, it only remains to look through the eyepiece and outline on the glass all the objects comprised in the scene, placing these outlines so that they exactly fit on the contours of the objects as seen through the glass. It is clear that a drawing so made cannot be anything but a completely accurate and truthful record of the view as seen from the fixed position of the eye.

It should also be clear that if the eyepiece is now discarded and the picture is looked at from any point of view other than that which the eyepiece defined, the drawing will cease to fit on the contours of the view. If the eye is brought closer to the drawing, each object will appear to cover a wider angle on the drawing than it does in the view, while if, on the contrary, the eye is taken further from the drawing, the objects in it will cover a narrower angle than in the view itself. The drawing is

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thus only correct when viewed from the precise distance that it was from the eye when made.

Exactly the same considerations apply in the photographic rendering of perspective. If two photographs were taken through the eyepiece, one before the drawing was made and one afterwards, so that the first was a photograph of the view itself and the second a reproduction of the drawing, the two will, of course, be found precisely identical as regards their outlines. Now it is easily proved, geometrically, that a photograph of a plane object, such as a drawing, is a completely faithful reproduction of the original. Since the drawing is itself in perfect perspective it therefore follows that the perspective of the direct photograph of the view is also perfect.

It can be shown, again by simple geometrical reasoning, that if the linear scale of the photograph is some fraction of that of the original drawing on glass, the correct distance from which to view the photograph is the same fraction of the distance between the glass and the fixed eyepiece. The photograph should, in fact, be viewed from a distance equal to the distance between lens and film at the time the photograph was taken, which distance, in all normal cases, is practically equal to the focal length of the lens. If the photograph is viewed from any distance other than the correct one, then, as in the case of the drawing, the perspective ceases to be accurate.

It is interesting to note here that the distortion of perspective said to be given by photographic lenses, and especially by lenses of wide angle, is completely non-existent. The impression of distortion, which is often considerable, is due to viewing the print from (in most cases) too great a distance. A quarter-plate print is normally viewed at some 10 inches from the eye; unless taken with a 10-inch lens, the perspective must appear incorrect. This apparent incorrectness will obviously be greater if the correct viewing distance is $3\frac{1}{2}$ inches (photograph taken with a $3\frac{1}{2}$-inch lens) than if it were 6 inches.

When a photographic print is made by enlargement, the correct viewing-distance is increased in the same ratio. I a quarter-plate negative made with a 5-inch lens is enlarged to whole-plate (2 diameters) the correct viewing distance becomes 10 inches, which is a distance at which the print is very likely to be held. Hence the "improved perspective" and more natural appearance of an enlargement as compared with a contact print.

The alleged "stereoscopic" effect produced by print-viewers that include a lens is at least partly due to the shortened

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viewing-distance that the lens permits. (On this point see VIEWER.) (See also DISTORTION.)

Petzval Lens. See LENS.

***p*H.** Term used in specifying the acidity or alkalinity of a solution. Acidity is due to the presence of hydrogen ions, alkalinity to that of hydroxyl (OH) ions. In pure water, both are present to the extent of 10^{-7} gm-ions per litre; since their concentration is equal, pure water is neutral. In all other aqueous solutions, the product of the concentrations of hydrogen and hydroxyl ions remains at 10^{-14}; the solution is acid or alkaline according to which ion preponderates. A solution containing 10^{-10} gm-ions per litre of hydrogen (and hence 10^{-4} gm-ions per litre of hydroxyl) is alkaline, and is said to have a *p*H of 10. Note that *p*H=7 indicates precise neutrality; higher figures indicate an alkaline solution and lower figures an acid one.

An ordinary (non-fine-grain) developer generally has a *p*H of about 9·5 to 10·5, while the less alkaline fine-grain developers range roughly from 7·5 (unusually low) to about 9. The *p*H of D76 is 8·6. A standard acid fixer will have a *p*H of about 4·2.

Phenidone. 1-phenyl-3-pyrozolidone, $C_6H_5N_2C_3H_5O$, M.W. = 162. Developing agent discovered by Ilford Ltd. in 1940 and introduced commercially in 1951. An active developing agent, prone to cause fog, and not well suited to use alone. Even in low concentration, it is a most vigorous activating agent for hydroquinone, the combination having the advantages over M.Q. of lower alkalinity for comparable activity, better keeping qualities (used or unused), slower exhaustion, and much less tendency to produce dermatitis in the user, or stains if spilt. Further, phenidone is much less readily salted out of solution than is metol, so that concentrated developers can be prepared without the use of caustic alkali. The high activity of phenidone makes it necessary to use one-fifth or less as much of it as of metol, but calls for the inclusion of an anti-foggant (benzotriazole) to prevent fog. A general-purpose developer based on phenidone (Ilford ID.62) is:

Sod. sulphite (anhydr.)	1 oz.	(50 gm.)
Hydroquinone	115 gr.	(12 gm.)
Sod. carbonate (anhydr.)	525 gr.	(60 gm.)
Phenidone	4½ gr.	(0·5 gm.)
Potass. bromide	17½ gr.	(2 gm.)
Benzotriazole	1¾ gr.	(0·2 gm.)
Water to make	20 oz.	(1000 c.c.)

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If Ilford I.B.T. restrainer is used in place of solid benzotriazole, use 3 drachms or 20 c.c. in place of the quantities given. Alternatively a 1 per cent. solution of benzotriazole in 1 per cent. (anhydr.) sodium carbonate solution may be used in the same amounts.

For contact papers, dilute 1 part of the above with 1 part water.

For bromide papers, or for the dish development of plates and films, dilute 1 part of the above with 3 parts water.

For tank development of plates and films, dilute 1 part of the above with 7 parts water.

Developing times for roll films; dish strength, $2\frac{3}{4}$ to $3\frac{1}{2}$ minutes; tank strength, $5\frac{1}{2}$ to 7 minutes, all at 68° F.

See also DEVELOPMENT and FINE-GRAIN DEVELOPMENT.

Photo-Cell. General term for any device that converts light energy into electrical energy. Besides the selenium barrier-layer cell used in photo-electric exposure meters, there is the vacuum photo-cell. This, unlike the selenium cell, is instantaneous in its response to light, but has no photographic applications except in scientific measurement—shutter-testing, for example.

Though not strictly a photo-cell, for it does not convert light energy into electrical energy, the recently introduced cadmium sulphide cell, the resistance of which changes according to the light falling on it, is also of interest to photographers.

See EXPOSURE METERS.

Photo-Electric Meter. See EXPOSURE METERS.

Photo-Engraving. See PHOTO-MECHANICAL PRINTING PROCESSES.

Photo-Finish Camera. Camera used on race-courses to record the finish of a race. It is set up above one end of the finishing line, and has a very narrow vertical field of view that includes practically nothing but the finishing line itself. The film is drawn through the camera at the rate at which the images of the horses are expected to move, so that they are approximately stationary on the film. The resulting negative accurately shows the order in which the horses reach the finishing line, but because the hind legs reach the line later than the front legs, the horse may be shown in quite an impossible attitude.

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Photo Finishing. Term applied to the commercial developing, printing, and enlarging of negative films, and the processing of reversal films.

Photoflood. Inexpensive overrun lamp of short life giving very considerable light output, at a high colour-temperature, for a moderate expenditure of electrical power. The No. 1 photoflood consumes 275 watts, gives a light-output of 8000 to 9000 lumens (equivalent to 6 to 7 100-w bulbs) and has a life of 2 to 3 hours. The No. 2 Photoflood consumes 500 watts, gives a light-output of some 16,000 lumens, and has a life of 5 to 10 hours. Colour temperature in each case, 3400° K. Normally the No. 1 lamp has a B.C., the No. 2 an E.S., cap. Both are widely used, generally in one of the inexpensive reflectors designed for them, for amateur work. Owing to their short life, photofloods are uneconomical if much work is to be done; a 500-w 100 hr. studio lamp or nitraphot is then to be preferred. See STUDIO LAMP, NITRAPHOT, and OVER-RUN LAMPS.

Photogrammetry. The art of making surveys or geodetical measurements by the aid of photography.

Photographic Alliance. A body whose members are the ten Federations (*q.v.*). Its main function is to provide a forum where matters of interest to two or more Federations—for example, the boundaries of the areas each shall cover—can be discussed. The Royal Photographic Society works in close conjunction with the Alliance, which is the ruling body in organized amateur photography. The permanent address of the Alliance is that of the Royal Photographic Society (*q.v.*).

Photography (*φωτός*, genitive of *φάος* or *φῶς*, light, and *γράφω*, I draw) is the art of obtaining the representation of objects by the agency of light upon sensitive substances. The following is a short history of the progress of the art:—In 1777 Scheele, the great chemist, discovered the important fact that silver chloride blackened in sunlight, the chief action lying in the violet end of the spectrum. In 1802 Thomas Wedgwood, son of the famous potter, published in the "Journal of the Royal Institution" an account of a method of copying paintings on glass, and of making profiles by the agency of light upon silver nitrate. In the experiments which are thus described he was assisted by Sir Humphry Davy. They managed to obtain images upon paper and white leather by means of the solar microscope, but were

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unable to fix them ; therefore the image was soon obliterated by the darkening of the whole surface. In 1814 Nicéphore de Niépce commenced a series of experiments, but although he managed to obtain images upon a bituminous film, the process was impracticable for ordinary purposes, from the inordinate exposure (several hours) which was required. He then, in partnership with Daguerre, carried on his experiments ; but it was not until 1839, six years after Niépce's death, that Daguerre communicated to the Académie des Sciences at Paris the process so well known as Daguerreotype. Early in 1839 Fox Talbot, previous to Daguerre's communications, announced to the Royal Society a method of " photogenic drawing," in which pictures were produced upon paper prepared with silver chloride. Fox Talbot effected the fixation of these pictures by saturated solutions of sodium chloride and potassium bromide. The use of sodium thiosulphate (" hypo "), however, soon became general, Sir Humphry Davy having, in 1821, published the action of this salt upon the salts of silver. In 1841 Fox Talbot patented his process called Talbotype or Calotype (*q.v.*). To the Rev. J. B. Reade is due the credit of first recommending a developer, although Fox Talbot was the first to use a restrainer. Up to this point paper negatives alone were in use ; but in 1848 a cousin of the original Niépce, M. Niépce de St. Victor, proposed the use of albumen on glass as a vehicle for the sensitive salts of silver. These plates, however, were very insensitive, and numerous substances, such as starch, gelatine, gum, etc., were proposed ; none, however, was successful. In 1851 Le Gray, of Paris, and Scott Archer, of London, proposed the use of collodion, the latter publishing such a complete description of the wet collodion process that but little improvement has ever been effected. A great disadvantage, however, of this process was the necessity of exposing the film whilst wet, necessitating the use of bulky and heavy impedimenta for the landscape photographer, in the shape of dark tent, etc. It was then discovered that the application of certain organic substances to the washed film would allow of the plates being used in the dry state. In 1862 Major Russell discovered the use of alkaline pyrogallol as a developer, and his accidental discovery of the restraining power of the soluble bromides gave the first impetus to the manufacture of silver bromide films, which could be exposed dry. In 1864 Messrs. Sayce and Bolton described the process of making collodion emulsion, which was poured upon glass plates, and then washed to free from

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inert salts. In 1874 it was discovered that the emulsion might be washed before coating, and in 1871 Dr. R. L. Maddox published a notice of a gelatine emulsion, and from that, in 1878, Mr. Charles Bennet realised the capabilities of the process and power of increasing the sensitiveness by digestion at high temperatures.

These last discoveries laid the final groundwork of modern photography, and though advances since then have been both great and numerous, they have on the whole taken the form of improvement rather than innovation. Continual improvement in emulsion-making has been the fundamental advance that has largely controlled all others; the steadily increasing speed of negative emulsions made the hand-camera first possible, then popular, and finally paramount. Simultaneously the improvement in emulsion quality, combined with the parallel development of bromide and allied papers for enlarging, has brought about a continual reduction in the average negative-size. The introduction of the roll film, too, first by George Eastman (1884) in the form of paper stripping film, and later (S. N. Turner, 1891) as a daylight-loading roll of celluloid film, brought photography within reach of millions who have never seen the inside of a dark-room, and never wish to. The effect of all this on camera design can be seen from the entries CAMERA and MINIATURE CAMERA, while a brief outline of the history of cinematography and of colour photography will be found under those headings.

Photogravure. See *Intaglio Process* in PHOTO-MECHANICAL PRINTING PROCESSES

Photokina. Name of a photographic trade fair held periodically at Cologne.

Photo-Lithography. See PHOTO-MECHANICAL PRINTING PROCESSES.

Photomaton. Name given to an automatic machine for taking a number of photographs in succession and delivering a strip or sheet of finished prints in 2 or 3 minutes. The prints are produced by a reversal method on a celluloid and paper base.

Photo-Mechanical Printing Processes. Methods by which are produced printing surfaces, from which impressions can be taken without light being concerned in the production of each copy.

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Relief Processes.

These processes are at present of most commercial importance, because illustrations in relief, *i.e.* line etchings, and half-tone screen or grain blocks, can be printed at the same time as type and on speedy printing presses, at a cost per impression which is relatively infinitesimal when large numbers are required.

Line Blocks.

A block is called a line block when the original reproduced consists of only two tones, black and white. In the case of these blocks it is the practice, in all workshops which turn out large quantities of work, to divide the work into the following departments :

(1) *Negative Making.*—The wet-collodion process is usually employed, as it yields a negative representing the blacks as clear, transparent spaces, and the whites as an extremely opaque deposit of metallic silver; moreover, the wet collodion film is very thin and gives a sharp clear-cut image. Dry plate manufacturers have of late years met with considerable success in their efforts to obtain wet collodion quality, and for certain purposes dry plates can be used where wet collodion is unsuitable. It should be remembered that negatives for line blocks, and also for half-tone, should be reversed either by copying through a prism fitted on the front of the lens or by stripping the film and turning it over. If this were not done the impression from the finished block would be wrong way round.

(2) *Making the Print on Metal.*—Polished 16-gauge zinc sheet free from scratches and dead flat, is commonly used though copper and brass are sometimes employed for special purposes.

The zinc is cut to the size required, and freed from grease by rubbing it with charcoal or fine pumice powder under running water. It is then coated with a solution of albumen and ammonium bichromate, and to obtain an even coating is whirled over gentle heat until dry. The sensitised plate, in contact with the negative, is placed in a specially stout printing frame the front glass of which is an inch thick and capable of heavy and even pressure. Exposure is to daylight, or more generally to a powerful enclosed arc lamp.

Wherever light acts, it has the effect of rendering insoluble the sensitive bichromated colloid coating on the metal; where no light reaches it, the bichromated colloid remains soluble. After sufficient exposure the metal is taken out of the frame and covered by means of a roller with a thin film

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of a special ink. The plate is then placed in a dish of clean cold water and gently rubbed with a pad of cotton wool. The soluble coating easily comes away, leaving the insoluble parts covered with ink. The plate is then dried and warmed, and the ink thus made tacky by warming is covered with either a resin or bitumen powder. The plate is then again heated to cause this to incorporate with the ink. If there are any defects, these are made good, and the back and sides coated with acid-resisting varnish. The plate is then ready for the next step.

(3) *The Etching.*—This consists in eating away the bare zinc representing the white spaces in the original to a sufficient depth by means of nitric acid, leaving the black lines standing in relief. It usually requires several etchings to obtain sufficient depth, the tops and sides of the lines being protected by means of ink and resin, or dragon's-blood powder, fused by heat before each successive acid bath. Then the accumulation of ink and resin which has formed the " resist " against the acid is cleaned off. If copper or brass is used, then the etching mordant is not nitric acid, but ferric chloride solution.

Other methods of sensitising the zinc plate which are frequently used are the enamel process, using bichromated fish-glue solution, and the cold enamel process, in which a bichromated shellac solution is used.

(4) *Mounting.*—Having trimmed the plate, routed away all waste metal and repaired any defects, the plate is often pinned down on to a piece of hard wood (usually mahogany), of such a thickness that the plate thus mounted is exactly type-high.

(5) *The Proofing.*—The surface of the block is now covered with an even film of fairly stiff ink. This is applied by means of a hand roller. A small quantity of the ink is placed on a slab, either glass or an old litho stone, on which it is rolled out evenly. The roller, to which a certain amount of ink adheres, is applied to the surface of the plate, on which it leaves a coating of ink. A paper impression can now be taken by means of a handpress or platen. The block is now complete and is ready for the printer.

Halftone Blocks.

In the making of halftone blocks the operations are essentially the same as for line. The halftone, however, has a much wider range of usefulness, for it can be used to reproduce any type of original, whereas for a line block only copy composed of firm black lines on a clean white ground is suitable. The halftone negative, however, differs in one important respect

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from a line negative. What is known as a cross line screen is placed in the camera in front of, but not touching, the sensitive plate. This screen consists of two optically plane sheets of glass each ruled with parallel black lines varying from 50 to 200 to the inch. The lines are of uniform thickness and equal in width to the clear spaces between. The two glass sheets are cemented together with canada balsam, the lines crossing the sides of the plate at an angle of 45°.

When the correct distance between plate and screen is found, a negative is obtained which splits up the continuous tone of the image into dots differing in size according to the varying brightness of the tones of the original. Except where an exact facsimile is required, most originals, if photographic prints, are better for a little retouching, especially if required for catalogue illustrations. Parts of the photograph requiring emphasis can be greatly improved by an experienced artist retoucher.

Printing on metal is almost entirely by the bichromated fish-glue process; copper and zinc are both used, but in England copper is preferred for better class work.

Bichromated fish-glue becomes insoluble in water when exposed to light. A halftone negative consists entirely of black dots and open spaces of varying size. The black dots of the negative prevent the light reaching the sensitive solution, whereas the open spaces let it through. The exposure finished, the plate is developed under running water; the solution protected from the light is washed away leaving bare metal, but where the light has penetrated the fish-glue is ready for etching. The etching fluid, ferric chloride for copper or nitric acid for zinc, eats away the unprotected metal but cannot penetrate the hardened fish glue. A printing surface of raised dots and etched-out spaces of varying sizes is now ready for trimming and mounting on wood.

Proofing is carried out as for line work, but a coated paper should be used for best results.

Three-colour Blocks.

The three-colour process is an application of the fact that three coloured lights suitably chosen can, either alone or mixed in varying proportions, approximately imitate any colour.

Place a coloured copy, such as a water colour painting, on the copyboard and illuminate with white light. Then with a blue-violet filter in front of or behind the lens, and using a panchromatic plate, make your exposure. Repeat the process

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using a green filter, and then again with a red filter. These filters are so adjusted that the first negative only records the blue light, the second the green, and the third the red reflected from the original. From these colour-separation negatives positives are made, and from the positives halftone negatives and blocks as for black-and-white work.

Care must be taken, however, to alter the screen angle for each negative to avoid objectionable patterns in the finished result.

Screens can be bought ruled at suitable angles for this purpose.

The blocks are printed with inks respectively absorbing the lights photographically recorded and reflecting light of all the other colours of the spectrum which are not photographed. The block made from the blue-violet filter negative is printed in yellow, which absorbs blue and reflects red and green. The block made from the green filter negative is printed in magenta-red, absorbing green and reflecting blue and red, and the block from the red filter negative is printed in blue, absorbing red and reflecting blue and green.

Yellow is usually printed first, then the red in exact register on the yellow, and finally the blue also superimposed in exact register.

The resulting impression should approximate to the original, but usually a certain amount of fine etching is necessary.

The method just outlined is known as the indirect process, and is now used chiefly for reproducing colour transparencies such as Kodachrome, or for object work.

Another method nearly always used for reproducing flat copy is the direct process. The colour records and halftone negatives are made at one operation by using the filter and cross-line screen in conjunction with a process panchromatic plate.

A fourth (black) printing is now often used, and if not over-done can be a distinct help by giving depth and richness to the shadows.

Surface Processes.

Lithography.—Photography is frequently employed by the lithographer to reduce accurately his original to the required scale. On the print made from the negative he makes a tracing that forms the key, which is transferred to the several stones used in order that they may correctly register with each other. A description of lithography is perhaps appropriate in order to enable a clearer understanding of photo-lithography (see under) to be arrived at. Lithography depends upon the

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fact that grease and water will not readily mix. A drawing is made with fatty ink or crayon upon a suitably prepared special kind of limestone. The stone is then coated with a solution of gum arabic and nitric acid, which forms a chemical compound with the parts not drawn upon, keeping them absorbent of water and repellent of grease, while greasy printing ink will adhere firmly to all other parts. The surface gum is washed off with water, the artist's ink washed off with turpentine and then, on passing a roller charged with printing ink over the stone, the ink takes upon the design only. To print the lithograph, the stone is damped and rolled up, paper laid on, and pressure applied.

The lithographic draughtsman draws upon the stone from the original design or picture which is to be reproduced. Autolithographs are drawn on stone without the intervention of another designer's copy. Drawings are frequently made on transfer paper and then transferred to stone. A separate stone is drawn for every colour used, and in the reproduction by chromo-lithography of paintings, the skill of the lithographic draughtsman consists in his selection of such printing colours as will faithfully reproduce the original in the fewest printings, which may, however, run to as many as thirty.

The practice of the craft may be divided into three parts :

1. The preparing of the stones.
2. The drawing of the design in fatty ink on to the stone.
3. The printing from the stone.

Photo-Lithography.

Photo-lithography is a process for the reproduction of originals by photographic means, applied to printing by lithographic methods.

A negative is made of the original and printed direct on the stone, zinc, or aluminium, sensitised with a coating of bichromated albumen ; the print is developed with water like a line-block print, and printed off as a lithograph. The negative may only consist of two tones, opaque black and transparent spaces, and it must be laterally reversed.

As an alternative method to printing direct, the negative may be printed on to a gelatine paper sensitised with a bichromate, and after the usual process of inking and development the image may be transferred from the surface of the gelatine to a lithographic stone.

Half-tone negatives, made by means of cross-line or grain

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screens, as well as transfers from collotype plates, are also used, and sometimes ordinary continuous-tone negatives are treated in various ways to secure a grained result suitable for lithographic printing, or the printing surface may be so prepared as to yield a grained result from negatives having no grain.

Collotype.

This is a surface process somewhat analogous to lithography inasmuch as it again depends upon the mutually repellent nature of grease and water. The difference consists in the material employed. A surface of bichromated gelatine is used instead of stone, and the design is put upon the surface by means of a photographic negative instead of being drawn by hand.

A thick glass plate is ground on the surface, coated with a substratum of potassium silicate, then coated with a solution of gelatine containing a bichromate, and dried at a certain temperature in the dark. When dry the film is sensitive to light; that is to say, wherever light acts upon it, it will become more or less insoluble and refuse to absorb water, while where the light is prevented from access the film remains absorbent of water. The bichromated film is exposed under a photographic negative, and after sufficient exposure the plate is thoroughly washed to remove all the unaltered bichromate, and allowed to dry. To prepare for the press the plate is flowed over with a solution of glycerine and water, which the gelatine will refuse to absorb in exact proportion as it has been affected by the light. After placing in a printing press, a roller charged with a greasy ink is passed over the surface. The film takes ink in proportion to the insolubility produced by light, and, if paper is laid on and pressure applied a collotype print will be the result. An average edition is 500 copies from each plate.

INTAGLIO PROCESS.

Photogravure is one of the oldest, and most beautiful (if not *the* most beautiful) of current reproductive processes. An ordinary negative is made of any copy, object, or landscape of which it is desired to make a photogravure. From this a reversed positive transparency on glass is made, either on a gelatine dry plate, or by the carbon process (*q.v.*). A piece of polished copper is now taken and cleaned to remove all traces of grease; it is then grained, *i.e.* finely powdered bitumen or resin is shaken up in a large box, called a dusting box, and after an interval, determined by the fineness or

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coarseness of the grain required, the copper plate is placed inside the box, and the particles of powder allowed to fall on the surface. These are then fixed to the plate by heating it, and in the etching they form little points which resist the mordant.

From the transparency a negative carbon print is made, and after exposure, but before development, the gelatine tissue is placed face downwards in contact with the grained copper while under water ; then development of the film takes place in hot water in the usual way. The high lights of the subject are now represented by the greatest thickness of gelatine, the half-tones by lesser and the shadows by least thickness. When the plate is dry and the back and sides have been protected by painting with an acid-resisting varnish, it is etched by placing it in baths of ferric chloride solution of various strengths. The gelatine film acts as a resist to this mordant, and where the resist is thinnest (in the shadows) the copper is etched deepest, and where it is thickest (in the high lights) the copper is attacked least. Sometimes some handwork is necessary on the plates, and this retouching consists in accentuating the lights by means of burnishing, or scraping smooth the copper, adding detail or intensifying shadows by means of cutting into the copper with a burin or a small toothed wheel called a roulette. The pure copper used being too soft to stand the wear of printing an edition of any number, the plate has to be " steel-faced," *i.e.* given an electrolytic coating of iron.

To print, ink is forced by means of a pad of canvas into the hollows etched in the plate, and the surplus wiped away from the surface and margins. All over the ground of the plate there are a number of little points of copper representing the places where the grain had fallen ; their function is to prevent the ink being wiped away from the hollows, as it would be if it were not for these spiky pieces enmeshing it. Damped paper is then laid on the plate, backed with soft blanketing, and hand-printed by means of a special press under a heavy iron roller. Machine-printed photogravure is now in quite common use for magazine and newspaper illustrations. For this work a fine screen plate supplies the grain and the etching is made on a copper cylinder instead of a flat plate. This can be printed in the rotary machines used for modern newspaper work.

Photometer, Photometry. In general, an instrument for measuring the output of a light-source, or the intensity of

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illumination at a point. The simplest form of photometer is an upright rod ; the two lights to be compared being so adjusted that they throw shadows of equal intensity on a screen, the luminosity of the two will then be in inverse relation to the square of the distance.

A more widely-used type of photometer is the Bunsen form, which consists of a piece of paper with a grease-spot upon it. By transmitted light the spot appears lighter than the surrounding paper; by reflected light it appears darker. When the light on both sides is of equal brightness, the spot is invisible.

This latter principle is frequently used in photometers intended for estimating exposures in enlarging ; a piece of paper bearing a grease-spot, and with a light of adjustable brilliance beneath it, is laid on the baseboard of the enlarger and the adjustable light varied until the spot disappears. This enables the brilliance of the part of the projected image in which the spot is placed to be measured with quite good accuracy. Sometimes a " representative " part of the picture, of medium brightness, is chosen as a basis of exposure ; more particular workers estimate highlight and shadows of the projected image independently, so measuring contrast as well as exposure required.

(See also EXPOSURE METERS.)

Photo-Micrography. The photography of minute objects by the use of a microscope in conjunction with a camera. Good records of microscopic objects can be taken by any amateur who possesses, besides a microscope, a camera with a focusing screen or a single-lens reflex.

It is vitally important that the whole of the apparatus should be " welded " together to avoid movement or vibration during exposure. This is best done by mounting camera and microscope together on a common baseboard, which should preferably be so designed as to allow the microscope to be used with its tube horizontal, and should provide means for sliding the camera to and from the eyepiece.

The lens of the camera is removed, its place being taken by the microscope, which is fitted to the camera in any convenient way. If the two are independently supported on the base, a flexible connection of black velvet between the two will exclude light while retaining freedom of movement.

Small objects, such as hairs of animals, wings and legs of insects, or vegetable fibres may be mounted between strips of glass bound together. An ordinary electric lamp will serve

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as the illuminant, and may conveniently be mounted in a black box with a small slit which is placed close to the stage.

Transparent objects are illuminated by transmitted light, but opaque objects are lit from the front, using a condenser to get brilliant illumination. The former method generally gives best results, and allows shorter exposures.

For further details, see *Amateur Photomicrography*, by Alan Jackson (Focal Press, 7s. 6d.).

Stereoscopic Photo-Micrography.—There is an old and very satisfactory method by placing the slide or object in a tilting frame attached to the stage of the microscope. The frame with the object being tilted to one side to the proper angle, a photograph is taken; the frame is then tilted to an equal amount in the opposite direction, and another photograph is taken. Prints from the negatives are then mounted in the usual way, to form a stereoscopic slide.

Photo-Montage. The process of producing a composite print by mounting together cut-out parts of several prints. The term is applied to prints mounted side by side to form a "page of pictures," but is perhaps even more often used where parts of one print are pasted on to another for such purposes as introducing figures into a view. The composite print is usually re-photographed to produce a final print in which the separate parts are no longer distinguishable as such. Montage is one of the most-used methods of producing photographs of impossible subjects—*e.g.*, a man boldly defying a mouse twice his own size.

Photo-mural. An over-size photographic enlargement pasted directly on to a wall as a form of wall-decoration. Such enlargements are often made in sections, or if frieze-like in style may be developed in long lengths by drawing them through a trough of developer. Prints too big for dish development may be processed by spraying or sponging.

Photon. The smallest amount of radiant energy (including light energy) that can be added to or taken from any system.

It has long been recognised that energy, like matter, is atomic in structure, and that just as one cannot have less than one atom of matter, one cannot have less than one quantum of energy. Like the atom, the quantum of energy is excessively small; in all our normal experiences, either with matter or energy, many millions of atoms, or quanta, are involved.

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When, however, research into the relationship between matter and energy is undertaken, as in considering the amount of light that must be absorbed by a single grain of an emulsion to render it developable, the fact that only an exact whole number of quanta of energy can be involved begins to obtrude itself.

In the case of light, the " atom " of energy is called the photon, and the amount of energy in each photon depends upon the frequency (or wavelength) of the radiation involved. A photon of blue light contains more energy than a photon of red light, and a photon of X-rays contains more energy still. The exact magnitude of the energy, in ergs, carried by a photon is found by multiplying the frequency of the radiation, in oscillations per second, by Planck's Universal Constant h, of value $6{\cdot}55 \times 10^{-27}$ erg-secs.

Photo-Telegraphy. A term which, while strictly meaning the transmission of messages by the aid of light, is often applied to the transmission of still pictures by wire or wireless.

Regular services are in daily use for the telegraphy of news photographs to newspapers, and postal services also exist for the transmission of commercial pictures. Photographs were first transmitted by Professor A. Korn from Paris to London in 1907, and later from Manchester and Paris to London in the Thorne-Baker " Telectrograph," until about 1909, when the high cost of these transmissions made them uncommercial. The art of photo-telegraphy then lay dormant until the advent of the amplifying valve and the modern photo-electric cell.

The modern process consists essentially of a rotating glass cylinder or a drum round which the photographic film or print is wrapped, and a scanning device which travels from one end of the drum to the other while the latter rotates. A light source and lens system focusses a point of light upon the surface of the drum, or passes through it in the case of a glass cylinder and film. The light is reflected back from the surface in the case of a print, falling then on the photo-cell. In this way the entire surface of the image is scanned, the variations in density causing corresponding changes in the electrical output of the cell. These are impressed on a carrier wave, and transmitted by wire or wireless to the distant receiving instrument.

The telegraphed impulses are reconverted into a facsimile image in various ways. One of these employs a galvanometer consisting of a fine metallic flat " string " stretched between

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the poles of an electromagnet. The poles are tunnelled so that a beam of light can pass through them, this being then concentrated on a sensitive film attached to a drum which is rotated synchronously with that of the transmitting instrument. The string, which in the position of rest intercepts the narrow light beam, shifts to one side with the incoming impulses, so that as the picture tones are lighter or darker so more or less light respectively reaches the film. On development, therefore, a reproduction of the original image is obtained.

Another method of reception depends upon the polarisation of a beam of light passing through a glass cell containing carbon disulphide. The received current is passed through coils or plates which rotate the plane of polarisation. Nicol prisms, fitted at each end of the cell, are so arranged as to extinguish all light when there is no current, but as the received currents affect the carbon disulphide so more or less light gets through the cell and acts upon the synchronously rotating film drum.

Yet another method of reception employs a microphone fitted with a stylus on the drum, which presses more or less strongly on a sheet of carbon paper and thus marks the paper lying between it and the drum. Another again uses a high frequency gas-filled lamp which glows more or less brightly according to the impressed currents and thus exposes the receiving film.

The time taken for a 10 by 8 inch picture to be transmitted over wires is 3 to 4 minutes. Owing to the perfection of synchronising methods and the ability to tune the amplifying circuits and to choose valve characteristics so that correct gradation is secured in the received picture, the quality of the telegraphed photograph is of a very high order, and large numbers of news pictures are used by modern newspapers, while there are official Post Office services for commercial picture telegrams.

A very important application of the wired photograph has recently been developed for the making of three-colour separation negatives, using scanning devices fitted with the appropriate filters and photo-cells selectively sensitised for the respective spectral regions. The transmitting and receiving drum are mounted on the same shaft, so that difficulties of synchronisation do not occur. Continuous tone photographs can also be broken up into half-tone negatives in the same way, a light chopper dividing the spiral lines of the image into dots of any pre-determined size.

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Physical Development. The development of the latent image by deposition upon it of silver contained in the developing solution itself, instead of making use, as in the more usual chemical development, of the silver already present in the emulsion.

The method of development used in the Daguerreotype and wet collodion processes was physical (see these entries) and in the latter case bears a close resemblance to the Wellington silver intensifier. (See INTENSIFICATION.)

Physical development was at one time advocated, notably by Odell, as a means of obtaining fine grain. For further details of this, see FINE-GRAIN DEVELOPMENT.

Pictorial Composition. The following points on this important subject for the photographer wishing to make pictures by photography are culled from *The Amateur Photographer* :—

The painter can change the forms and colours of a landscape to suit his purpose. The ordinary amateur photographer must accept the subject as nature presents it to him. The only thing he can do is to choose his point of view, the time of day when the light is most suitable, and perhaps introduce some figures in a suitable place. The artist photographer, who sets out to make a picture by the use of various negatives, super-printing, and other methods, is very much in the same position as the artist painter, and must be equipped accordingly, not only with a knowledge of the laws of composition but also the artistic ability to use them.

There are several of these laws or principles which are known to all designers, and are exemplified in nearly all objects of household decoration. Of these chiefly applicable to the landscape artist we might enumerate the following :—

1. *Principality and Subordination*, the great object of composition being always to secure unity ; that is, to make one complete picture out of many objects. The first mode in which this can be effected is by determining that one feature shall be more important than all the rest, and that the others shall group with it in subordinate positions. This is the simplest law of ordinary ornamentation known to all designers, and, incidentally, no doubt, to all who have done landscape photography.

2. *Repetition.*—Another important means of expressing unity is to mark some kind of sympathy among the different objects. This is best done by repeating certain groups, not symmetrically in imitation of each other, but with variations

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in form and size, so that one becomes a sort of broken echo of the other.

3. *Continuity.*—Another important and pleasant way of expressing unity is by giving some orderly succession to a number of objects more or less similar. And this succession is most interesting when it is connected with some gradual change in the aspect or character of the objects. The succession of pillars in a cathedral aisle is most interesting when they retire in perspective, becoming apparently smaller and more obscure in the distance. The succession of mountain promontories, one behind the other, on the flanks of a valley; or the succession of clouds fading farther and farther towards the horizon, each promontory and each cloud being of a different shape, yet all evidently following a certain appointed order.

4. *Curvature.*—As curves are more beautiful than straight lines, it is necessary to a good composition that its continuities of objects or masses should fall rather in curved lines than in straight or angular ones.

5. *Radiation.*—Another way of producing harmony, especially amongst groups of lines or objects, is to unite them together by radiation; that is, by their all springing from one point or closing towards it. This is an essential part of the beauty of all vegetable form; it is most simply seen in a single flower or leaf, but more beautifully in the complicated arrangement of large boughs and sprays.

6. *Contrast.*—In art, every colour has an opponent colour, which, if brought near it, will relieve it more completely than any other; every form or line may be made more striking to the eye by an opponent form or line near them; a curved line is set off by a straight one; a massy form by a slight one, and so on; and in all good work, the value which any given colour or form would have uncombined is nearly doubled by contrast. And yet a too manifest use of this artifice tends to vulgarise a picture. Great painters do not commonly admit violent contrasts.

7. *Balance and Symmetry.*—Balance is closely allied to symmetry, but in nature this symmetry is never formal nor accurate, as it generally is in a design for some object of applied art, such as a wall-paper or carpet. In landscape, one group of objects may be balanced by an entirely different group in another part of the picture. In figure composition this law is exemplified in many of the works of the Italian painters.

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Perugino's "Madonna," with the Angel Michael on one side and Raphael on the other, is a beautiful example.

Pigeon Post. An ingenious application of micro-photography, carried out by M. Dagron, during the siege of Paris in the Franco-German war of 1871. Messages to those outside were set up in type and reduced by photography so considerably that a bundle of films weighing 15 gr. (1 gm.), and forming the load for a pigeon, contained over 80,000 words. On the safe arrival of a pigeon at its destination, the messages were transcribed and forwarded. (See also AIRGRAPH.)

Pigment Processes. See CARBON PROCESS, ARTIGUE'S PROCESS, GUM-BICHROMATE, OZOTYPE, OIL-PIGMENT, BROMOIL, OZOBROME and CARBRO PROCESSES.

Pinacryptol Green. See DESENSITISING AND DESENSITISERS.

Pinhole Photography. Photography in which a pinhole is used in place of a lens. As a pinhole has no focus, objects at all distances are equally sharply rendered, and it can be used at any distance from the sensitive surface. The same pinhole can be used at one moment as a wide-angle and at the next as a long-focus lens, simply by altering the extension of the camera. The image is never quite sharp, but increases in sharpness, up to a point, as the diameter of the pinhole is reduced. With too small a pinhole, diffraction causes the image to become more blurred again; there is therefore a "best size" of pinhole for each extension. Quite wide divergence from the best size is, however, necessary before the loss of definition becomes noticeable.

A pinhole is most easily made by driving a needle through a sheet of metal foil; the burr is then cleaned off, and the needle is passed through again. The metal is then blacked, and put into the camera in place of a lens. The following table gives opposite the number by which needle-size is rated, the diameter of pinhole made, the extension for which it is best suited, and the Watkins-Power number on which exposure is based.

To calculate exposure, a kind of false *f*/number is obtained by multiplying the W.P. number for the pinhole by the camera extension (pinhole to film or plate). Exposure is worked out in seconds for this *f*/number, but in actually exposing minutes are used in place of seconds. This device is necessary to bring the *f*/numbers within the range of the meter scales. Using a pinhole of W.P. No. 8 at 6 in. from the plate, exposure is found for *f*/48. If this is half a second, half a minute is actually given.

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Needle No.	*Diameter.*	*Best Distance.*	*Circle of Confusion.*	*W.P. No.*
4	0·036 in.	20 in.	$\frac{1}{50}$ in.	4
5	0·031 in.	15 in.	$\frac{1}{60}$ in.	5
6	0·029 in.	13 in.	$\frac{1}{65}$ in.	$5\frac{1}{2}$
7	0·026 in.	10 in.	$\frac{1}{72}$ in.	6
8	0·023 in.	8 in.	$\frac{1}{82}$ in.	7
9	0·020 in.	$6\frac{1}{2}$ in.	$\frac{1}{94}$ in.	$7\frac{1}{2}$
10	0·018 in.	5 in.	$\frac{1}{105}$ in.	8
12	0·016 in.	4 in.	$\frac{1}{120}$ in.	10
13	0·013 in.	$2\frac{1}{2}$ in.	$\frac{1}{150}$ in.	12

A recent article by L. A. Turner (*Amer. J. Phys.*, 8, 112–115, April, 1940), contains an improved theoretical treatment of pinhole work. The author shows that the optimum radius of pinhole is given by the formula :

$$r = \left[\frac{1.2\,\lambda\, vu}{u+v}\right]^{\frac{1}{2}}$$

where λ = wavelength of light used
u = distance of object from pinhole
v = distance of image from pinhole.

The criterion for best resolving power that leads to the figure 1.2 in the formula is not very definite, and it is worth noting that if 0.9 is used instead the formula closely agrees with some experimental work done by Lord Rayleigh to find the best definition. In ordinary landscape or architecture work, v is small compared with u, so that the formula may be simplified to : $r = (1{\cdot}2\lambda v)^{\frac{1}{2}}$.

Figures calculated from this, using the factor 0.9 in place of 1.2, agree closely with those in the table on the preceding page if worked out for $\lambda = 4500$ A. (blue light). They are therefore correct for non-colour-sensitive material ; the distances should be reduced by about 12 and 20 per cent. for orthochromatic and panchromatic emulsions respectively.

Circles of confusion are difficult to assess accurately, as they have no definite limits ; those given in the table are at least a very good guide to the standard of definition that may be expected in pinhole work.

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Pinholes. Minute transparent spots on the negative. They are chiefly due to particles of dust adhering to the film during exposure or whilst in the developer. To obviate these the camera should be kept absolutely free from dust, but where pinholes are in existence recourse must be made to retouching or painting them out.

Plain (Salted) Papers. Home-prepared paper for daylight printing, in which the sensitive salt used is silver chloride. This process, from which albumen printing later developed, gives matt prints, and practically any pure paper can be used. The paper is first coated with a size containing an alkaline chloride, is dried, and is then sensitised with silver nitrate. After printing, the print is gold-toned and fixed much like a P.O.P. print. Many formulæ have been produced, but the following instructions are typical of them all.

Sizing and Salting—Weigh out :—

Arrowroot	192 gr.	(22 gm.)
Ammonium chloride	144 gr.	(16·5 gm.)
Citric acid	15 gr.	(1·7 gm.)
Sodium carbonate	30 gr.	(3·4 gm.)

Rub the arrowroot into a thin cream with an ounce (50 c.c.) of water, bring a further 7 oz. (350 c.c.) of water to the boil and pour the arrowroot cream into it in a thin stream, with stirring. Boil until a perfectly clear jelly is obtained (about 5 minutes.) Dissolve the chemicals in about 2 oz. (100 c.c.) of water, add to the arrowroot jelly, and allow to cool. Filter if necessary.

For more brilliant prints, add 1½ gr. (0·15 gm.) of potassium bichromate to the above ; for softer prints, add 2½ gr. (0·25 gm.) of sodium phosphate.

To apply to the paper, measure out the above at the rate of ½ minim for every square inch of paper (0·5 c.c. for 100 sq. cm.). Pin paper flat and taut on a board, using *glass*-headed pins, pour the salted size on to the middle of the paper, and spread it evenly with a flat sable brush about 3 in. wide. As soon as the paper is evenly coated, work over it with a round hogs-hair stippling brush, using overlapping circular strokes, until the paper is surface-dry. Then dry in a warm place.

Sensitising.—Prepare :—

Silver nitrate	70 gr.	(8 gm.)
Citric acid	20 gr.	(2·3 gm.)
Water	1 oz.	(50 c.c.)

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This solution is applied in the same quantity, and in the same way, as the salted size. When dry, the paper is ready for printing.

Matt Albumen Paper.—A method of preparing paper which gives results intermediate between those of plain salted and albumen papers, is the following, which is due to Hübl.

Prepare :—

White of egg . . .	1 oz.	(100 c.c.)
Arrowroot solution . .	1 oz.	(100 c.c.)
Salt	30 gr.	(6·3 gm.)

The albumen must be whipped to a froth, and allowed to stand 24 hours to clear. The arrowroot solution must be made as described, and when its temperature has dropped to 90° F. the two solutions can be mixed ; it can then be brushed on to the paper. The sensitiser for this may either be a plain solution of silver nitrate, or the above-given formula with half the amount of citric acid.

Printing and Toning.—The paper, of either type, is printed by daylight under a negative, which must have strong contrasts. Printing is carried on till the print is deeper than it is required to be when finished. The print is then kept on the move for 5 to 10 minutes in a salt solution of strength about 1 to 1½ per cent., and then washed briefly. Almost any weak toning bath may be used ; it should contain about 1 part in 10,000 of gold. A suitable formula is :—

Gold chloride . . .	1 gr.	(0·1 gm.)
Precipitated chalk . .	110 gr.	(12·5 gm.)
Water	20 oz.	(1000 c.c.)

Shake well, stand till clear, and decant. This bath gives purple and purple-brown tones. For sepia and brown-black platinum toning is used. The following is satisfactory :—

Potassium chloroplatinite .	2 gr.	(0·2 gm.)
Dilute phosphoric acid . .	¼ oz.	(12·5 c.c.)
Water	20 oz.	(1000 c.c.)

The salt bath mentioned above is essential, and prints must be well washed before fixing. For rich warm blacks, tone in gold till the colour just begins to change, wash well, and transfer to the platinum bath.

Fix in 10 per cent. hypo, made slightly alkaline with sodium carbonate.

See also KALLITYPE.

Plate-holder. See DARK SLIDE.

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Plate Speeds. See SENSITOMETRY; also EXPOSURE, EXPOSURE METERS.

Plates. The photographic glass plates coated with sensitive emulsion upon which the exposure is made for the production of negatives by subsequent development are usually referred to simply as "plates," or "dry plates" as distinct from "films." After exposure and development, both plates and films are referred to as "negatives."

Platinotype. A contact printing process based on the reduction of a ferric salt to a ferrous salt by the action of light. The ferrous salt is in turn made to reduce a platinum compound to metallic platinum, this forming the final image. Owing to the chemically inert nature of platinum, a print so made is far more permanent than any print having a silver image can be. No emulsion is used, so that the picture lies on the natural surface of the paper, allowing prints of distinctive character to be made.

The high cost of platinum, and the need for a large negative of high contrast, have made the process entirely obsolete, and commercially prepared paper is no longer available. Paper may, however, be sensitised by hand without much difficulty. The formulæ and instructions given here are largely due to Paul L. Anderson (*American Photography*, Oct., 1937, and July, 1938).

The paper used should be of high quality, and if extreme permanence is desired a linen paper should be used. Drawing-paper of most types is suitable, and some varieties may with advantage be sized. For this, soak 150 gr. (11 gm.) of opaque gelatine in 30 oz. (1000 c.c.) of water for half an hour, and dissolve on a water-bath at 140° F. (60° C.). Add 45 gr. (3·4 gm.) of powdered alum, 7 oz. (225 c.c.) of methylated spirit and filter into a dish. Immerse the paper bodily in this, breaking all air bubbles; soak for 3 minutes and hang up to dry. A second treatment may be necessary with some papers.

The solutions needed for sensitising are :—

1.	Oxalic acid . . .	16 gr.	(1·8 gm.)
	Ferric oxalate . . .	240 gr.	(27 gm.)
	Distilled water to . .	2 oz.	(100 c.c.)

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Platinotype

2.	Oxalic acid . . .	16 gr.	(1·8 gm.)
	Ferric oxalate . . .	240 gr.	(27 gm.)
	Potassium chlorate . .	4 gr.	(0·45 gm.)
	Distilled water to . .	2 oz.	(100 c.c.)
3.*	Potassium chloroplatinite .	184 gr.	(21 gm.)
	Distilled water to . .	2 oz.	(100 c.c.)

The ferric oxalate should be in the form of dry, bright green scales; if brown, or if the scales show a tendency to stick together, the sample should be rejected. The chloroplatinite should be in the form of dry, clean crystals of ruby-red colour. All three solutions should be stored in the dark or in brown bottles.

For coating, use a flat paint-brush with short hairs set in a thin row. Preferably they should be set in rubber. The paper is pinned to a flat board, or clipped to a sheet of glass, and just enough solution to coat it is mixed in a small measure or an egg-cup. For full black shadows, about 175 minims per 100 sq. in. of paper (1·6 c.c. per 100 sq. cm.) will be needed; for prints in which the darkest shadows are only grey, amounts down to 60 minims per 100 sq. in. (0·55 c.c. per 100 sq. cm.) may be used, provided the brush does not absorb too much of the liquid. The relative qualities of No. 1 and No. 2 solutions control the contrast of the print.† For normal contrast take—

Solution 1	7 parts
Solution 2	4 parts
Solution 3	12 parts

For soft prints, replace some or all of Solution 2 with an equal amount of Solution 1; for more contrasty results, similarly replace Solution 1 with Solution 2.

Pour the mixture in a pool in the centre of the paper, and at once spread it with the brush. Continue brushing till the paper is surface dry, and then dry in warm air or before a fire, and with the aid of a fan, in 5 to 10 minutes. The paper must be dry enough to crackle when flexed, and it must either be used at once or stored in a calcium tube. Coating can be carried out in ordinary room light if not too intense; the paper should be dried in almost complete darkness.

* For palladiotype, replace this with

Potassium chloropalladite	130 gr.	(14·8 gm.)
Distilled water to . .	2 oz.	(100 c.c.)

† With palladiotype, this control is less marked.

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Printing requires about 5 minutes in sunlight or correspondingly longer in the shade, behind a negative of normal density. The paper is sufficiently exposed when all detail in the image is visible in a brownish grey colour, the unexposed margins remaining yellow. The paper must be kept absolutely dry; printing should be rapid (in the sun if the negative is not too thin) and a sheet of thin indiarubber should be placed between the paper and the back of the frame.

Development is conducted by immersing the print, at room temperature, for 1 or 2 minutes in one of the following solutions.

For neutral black tones :—

Hot water	24 oz.	(500 c.c.)
Potassium oxalate . . .	8 oz.	(160 gm.)

For cold blacks, use :—

Hot water . . .	24 oz.	(500 c.c.)
Potassium oxalate . . .	4½ oz.	(90 gm.)
Potassium phosphate (monobasic)	1½ oz.	(30 gm.)

For warm blacks, use :—

Hot water	24 oz.	(500 c.c.)
Potassium oxalate . . .	8 oz.	(160 gm.)
Mercuric chloride . . .	30 gr.	(1·3 gm.)

The warmth of the tone is controlled by the amount of mercuric chloride used.* All these developers keep well, and may be used repeatedly.

When development is complete, clear in three successive baths of 1½ per cent. hydrochloric acid,† leaving the print 5 minutes in each, then wash and dry.

Increased contrast may be obtained‡ by adding a small amount of potassium bichromate (about 0·1 per cent.) to the developer. Reduced contrast can be had by adding a few drops of the dilute acid used for clearing; care must therefore be taken that none of this gets into the developer by accident. Warming the developer, up to 160° F. (70° C.), also gives reduced contrast and a warmer tone.

Platinum Printing-Out Process.

In this process, due to Pizzighelli, the image appears at full strength during printing, after which it only requires clearing

* Palladium, which in any case gives a warmer tone than platinum, is not very sensitive to mercuric chloride as a means of further increasing warmth of colour.
† For palladiotype prints, reduce the strength to ¼ per cent.
‡ This is ineffective with palladium prints.

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in dilute hydrochloric acid as above. To secure this behaviour, an oxalate (the usual developing agent) is incorporated in the sensitising mixture, so that development takes place as printing proceeds. Since a trace of moisture is necessary for this, the paper is too inconstant in its behaviour for the process to be really practical.

Playertype. See REFLEX COPYING.

Pneumatic Release. A form of shutter-release now superseded for most amateur work by the flexible wire release. It consisted of a ball and tube, the latter ending on a cylinder on the shutter itself, so that on compressing the ball the resulting air-pressure drove a piston down the cylinder and so released the shutter. In another form, chiefly used with roller-blind shutters, the tube ended in a small teat. This, normally flat and empty of air, was inflated by pressing the bulb, and in its expansion it moved a catch to release the shutter.

Poisons. None of the chemicals used in ordinary photography is in any sense dangerous if used normally; on the other hand, almost any photographic solution or chemical will give rise to more or less unpleasant symptoms if taken internally in sufficient quantity. It is therefore a sensible precaution to keep photographic chemicals in a place where they cannot possibly be mistaken for medicines or beverages, or inadvertently used in cooking.

Nevertheless there are a few chemicals, mostly used in special processes, with which no liberties should be taken. The following paragraphs show how these substances may be handled in safety.

Acids. With the exception of oxalic acid, no acid used in photography is in the least poisonous in the true sense, though several are intensely corrosive if sufficiently concentrated. A few drops of concentrated sulphuric acid (oil of vitriol) placed on the tongue would cause extreme pain and extensive damage; the same amount of acid, diluted with half a cupful of water, could be drunk without producing any ill effects whatever.

Concentrated sulphuric and nitric acids are immediately destructive if they reach mouth or eyes, or even a slight abrasion of the skin; to whole skin, on the other hand, they do no appreciable harm for several seconds. Neither should ever be handled except within immediate reach of a tap under which any acid reaching the person (or clothes) can be washed

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away with a copious stream of water, which instantly renders it harmless. The same precaution is advisable with concentrated hydrochloric and glacial acetic acids, though these are much less corrosive than either of the other acids mentioned.

Note also that when sulphuric acid and water are mixed much heat is generated ; if water is poured on to the concentrated acid the water may boil and sputter hot acid into the face. To dilute sulphuric acid, pour it in a thin stream into water, with continuous stirring, and if the solution gets too hot leave it to cool before adding the rest of the acid.

Oxalic acid and its salts (oxalates) are poisonous if taken internally, even in small amounts, but are quite non-corrosive. It is best not to allow them to come into contact with broken skin. Other acids used in photography are neither corrosive nor poisonous, unless swallowed in fair quantity.

Alkalis. Caustic soda and caustic potash, in solid form or in concentrated solution, are decidedly corrosive. Special care should be taken in breaking sticks or lumps to avoid all chance of small particles reaching the eyes. It is sufficient to wrap the stick in paper and to turn the head away, or close the eyes, at the instant of breaking it. As with corrosive acids, a copious stream of water should be used to remove any solid, or strong solution, that may reach skin or clothes.

Even strong ammonia is not seriously corrosive to skin or clothes, but its vapours actively attack eyes, nose and throat. To reduce the amount of vapour given off, strong ammonia should if possible be diluted to half strength as soon as bought ; this will also reduce loss of strength in storage. It is best to handle strong ammonia in a slight draught blowing the vapours away from the operator.

No precautions are necessary in handling other photographic alkalis.

Developing Agents. Most of the ordinary developing agents require no special care in handling (though all will produce stains if spilt). Metol and paraphenylene diamine are liable to cause skin trouble with a few specially susceptible persons, but the chief danger is from the dry substance rather than solutions. If any dry chemical that may reach the skin is washed away, and solutions, including developers, are never allowed to dry on the skin, no normal persons need take any further precautions.

Diethylparaphenylene diamine, often used as a colour-forming developer, should be treated with special care, as it can readily cause dermatitis, and any dust that may be

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inhaled can produce a most unpleasant inflammation of the mucous membrane.

Cyanides. All cyanides (*not* including ferricyanides or sulphocyanides) are exceedingly poisonous ; so much so that even a fairly weak solution should not be allowed to come into contact with broken skin. Further, cyanides, especially in acid solution, give off a vapour, smelling of bitter almonds, that it is dangerous to inhale. Handle solid or solution with spatula or forceps, and never use cyanides except in a well-ventilated room with a draught carrying vapours away from the operator. Then, and then only, cyanides are safe to use.

Mercury. Metallic mercury (quicksilver) is poisonous, and even the vapour, if one is exposed to it for long enough, can be dangerous. A few hours of exposure to the vapour do not matter in the least, but if some hours are spent every day in a small room in which there is an open or badly sealed bottle of mercury, serious symptoms—loss of teeth or hair, inflammation of the kidneys—can appear after a year or two. Any mercury spilt must be most scrupulously collected and disposed of, and any supplies of liquid mercury, if not in a completely sealed bottle, should be kept in the attic, garage, or toolshed and not in a much-used living room or dark-room. Liquid mercury should never be allowed to go down a drain, as it attacks the lead of the pipes, in which eventually a hole will appear. Mercuric salts are poisonous enough to make it advisable not to allow solid or solution to come into contact with broken skin, but are otherwise perfectly safe to handle.

Other Chemicals. No special precautions are needed in dealing with photographic chemicals not mentioned above, though it is a sound general rule to allow no chemical to come into contact with broken skin. Further, no dry chemicals should be left for long on the hands, and after wetting the hands with any solution they should never be dried on a towel without first rinsing the solution away under the tap. Habitual failure to observe the latter precaution is a very common cause of chemical dermatitis.

Polarising Filter. A filter that suppresses light vibrating in one particular plane, while freely passing light vibrating in a plane at right angles to this. Light reflected from a polished surface—glass, water, polished wood, glossy enamel, etc.—is to a large extent polarised, which means that it vibrates almost entirely in one plane. It is in photographing a subject containing reflecting surfaces that a polarising filter placed

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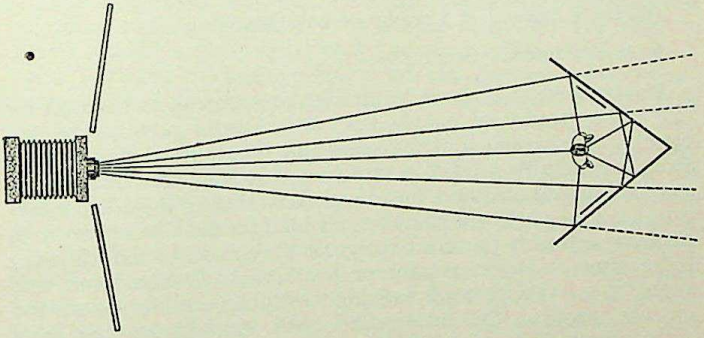
over the lens is of value. By so turning the filter that the plane in which it suppresses light coincides with the plane in which the reflected light is vibrating, the light reflected from the polished surface does not enter the lens of the camera, and so the reflection does not appear in the photograph. The polarising filter is of particular value in commercial photography.

Polypose. An old term for a photograph in which the same person is shown in several poses. This may be achieved



either by double exposure or with the help of mirrors. A simple double-exposure method depends on covering half the front of the lens hood with black paper, adjusted by trial so that only half the focusing screen is illuminated. An exposure is then made to record half the view; the hood is then turned round and a second exposure made for the second half. A dark line along the division indicates that too much, and a light line too little, of the hood is covered. With the camera on a stand, the same person may be included in each half of the picture.

With two mirrors of large size, placed face to face with the sitter between, reflection and re-reflection can be so arranged that the sitter in each of the mirrors appears as a series of copies of himself arranged in a row, side by side. Placing the mirrors so that their edges meet at an angle of 75° (see diagram), and letting the sitter face the angle, five different views of the same subject are obtained, all giving essentially different views of the face. It will be seen from the diagram that the camera is arranged to point between two plain screens

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to prevent any part of the room near the camera coming into reflection.

P.O.P. An abbreviation for " Printing-out Paper," a term which may be applied to any paper in which an image is produced by exposure alone, as distinct from those in which it is only revealed by subsequent development. In normal usage the abbreviation P.O.P. always means gelatino-chloride paper (*q.v.*).

Portrait Attachment. See SUPPLEMENTARY LENS.

Portrait Film. A variety of cut film (*q.v.*)

Portrait Lens. See LENS.

Portraiture. It is so common for cameras to be used for the photography of people that it is hardly possible to say exactly where snapshotting ends and true portraiture begins. But as generally used, " portraiture " implies that the photographer has had some measure of control over lighting, background, and pose, and that he has made a definite attempt to produce either a pictorial study or a representation showing something of the character of the sitter. Deliberation and thought on the part of the photographer, and co-operation on the part of the sitter, are both implied by the term " portraiture."

Portraiture was the first, and for long the chief, application of photography. The professional has continued on more or less conventional lines evolved in the course of regular studio work, with standardized apparatus and lighting, whereas amateurs have often been more original and adventurous in their tendencies.

The most essential equipment for portrait work is a camera fitted with a lens of focal length considerably greater than that normal for the size of negative being made. This is needed to obtain a head of good size on the negative without being compelled to bring the camera close to the sitter, a proceeding that invariably results in an over-accentuation of perspective, giving a result that is often more of a caricature than a likeness. Failing a long-focus lens, the worker will have to be content to make his final prints by considerable enlargement of a small portion of his negative. No exact rule can be given, but in general it is unwise to bring the camera nearer to the sitter than about seven to ten feet, and a greater distance is usually preferable.

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The size and type of camera is largely a matter of personal preference, though a camera making very small negatives is on the whole to be avoided, particularly if no long-focus lens is available. The reason is simply that graininess and blemishes are more noticeable in portraiture than in any other type of subject, and the larger the original image on the negative the more completely such faults can be avoided. If retouching of the negative is contemplated, nothing much smaller than half-plate, or quarter-plate at the very least, should be considered.

It is important, too, that the camera should be one capable of being rigidly mounted on a stand, and that the shutter fitted should have a good range of slow speeds that can be used without causing vibration of the camera. Most portraits are taken with an exposure of about half to a tenth of a second.

In embarking upon portraiture in an ordinary room, the background is often a difficulty. A plain wall is suitable, as are unpatterned curtains thrown well out of focus, or a special roll-up canvas background of light tint on one side and dark tint on the other may be bought or made. The exact depth of background tone on the print can be varied within wide limits by controlling the amount of light falling on it at the time of the exposure. For head-and-shoulder portraits, and even half-lengths, a background of size five feet by four is large enough.

For indoor portraiture by daylight a reflector is desirable to throw light on to the side of the sitter away from the window. A light wooden frame, about 4 × 5 feet, covered with white calico, or even white paper, is convenient, but improvisation is often possible. A diffusing screen is also useful; it may take the form of a wooden hoop covered with tracing linen. But such a screen is only really useful if it can be moved and adjusted readily, and then fixed in the required position. The effects obtained with the screen close to the sitter are totally different from those obtained by covering the window itself with a diffusing medium.

Nowadays, however, most portraits are taken by artificial light, using photoflood or similar lamps in reflectors. Suitable stands may be bought or improvised at home; they should be movable, and adjustable both for height and angle. Usually a secondary lamp, often of lower power than the main lamp or covered with a diffuser, replaces the reflector suggested for daylight work.

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Portraiture

Panchromatic film is generally preferred to orthochromatic, as it gives a softer rendering of skin texture. When working by artificial light, a pale blue filter is often useful; in its absence lips often reproduce too light, and blue eyes too dark. With orthochromatic film, on the other hand, lips, especially if lipsticked, usually reproduce too dark, and skin texture may be rather coarse. Many prefer orthochromatic film for portraits of men, and panchromatic for portraits of women.

The development of the negative and the lighting of the subject have to be considered as one problem. A soft lighting, with the shadow side of the face not much less brightly lit than the other, calls for rather long development; contrasty lighting with heavy shadows, on the other hand, calls for short development. For most subjects, soft lighting and fairly full development is best, but the untrained eye almost invariably under-estimates the contrast of the subject. Hence the usual advice to cut development time short for portrait subjects.

The accompanying diagrams may help the beginner to understand the art of lighting, which is the key to successful portraiture. The sketches show the plan of an ordinary room, and are almost self-explanatory. They are based on the use of daylight, but the modifications needed to adapt them to artificial light work are simple, and are explained below the diagrams themselves.

In (1) there is a strong light from one side only, which will produce somewhat violent contrasts of light and shade on the face of the sitter.

In (2) the arrangement of the background, sitter and camera in relation to the window is unchanged, but a reflector screen has been added to lighten the shadow side of the face. The nearness and angle of this will affect the modelling considerably and should be experimented with to achieve the best results.

In (3) a much softer lighting is secured by having the sitter further away from the source of light. This can be rendered softer still by means of a diffusing screen placed between the light and the face. Here again the reflector can be manipulated and placed in different positions and at different angles to secure a variety of modelling.

In (4) flat front lighting is secured by the arrangement shown. Here the sitter is facing the light and this position is suitable for obtaining high key results. For this purpose a light toned background should be used and the sitter also in light or white clothes. A certain amount of modelling can be

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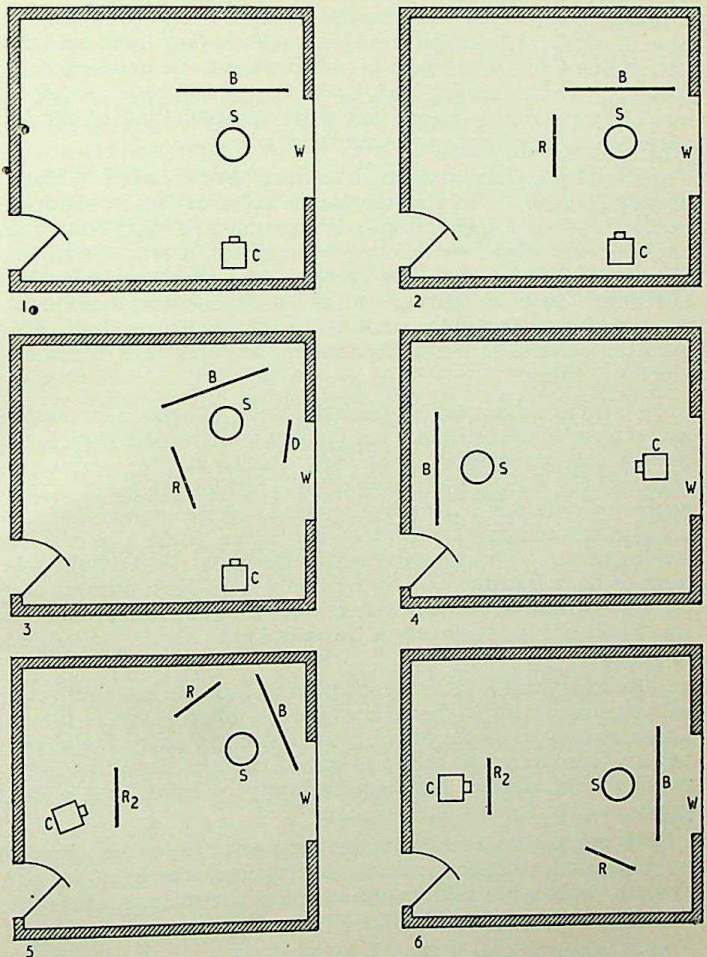

FIG. 1. The above sketches show in plan a room arranged for portraiture at home. (W) is a single window admitting good north light, but shielded at the bottom. (S) is the sitter; (C) the camera; (B) the background; (R) the reflector; (R_2) secondary reflector with hole cut in centre, as described in text. (D) diffuser. For artificial light work the main illuminant would be at the place occupied by the window and a secondary light could be used in place of the reflector. A diffuser may be necessary with lamps to help soften the direct light.

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introduced to this lighting by the aid of a reflector, or, in the case of artificial light, by the aid of a secondary light high up and to one side. This form of lighting has to be handled very carefully, or the results may be so flat as to produce insipid and characterless portraits, but with the right kind of model very decorative effects are sometimes possible.

(5) is the arrangement for securing the so-called "Rembrandt lighting." In this the face is more or less in shadow, but with a bright edge of light or concentrated light from one angle. Very slight movement of the sitter in relation to the source of lighting and the camera will effect considerable alterations in this lighting. It is an excellent arrangement for experiment to secure striking and dramatic results. The reflector is useful here to lighten the shadow side or to introduce a cross lighting.

(6) is an arrangement for back lighting. This is more easily achieved by artificial light when one lamp can be placed directly behind the sitter, who completely shields it, but leaving a glow of light showing as a sort of halo behind the head. This generally calls for a dark background. A secondary light is used to illuminate the front of the sitter, or in the case of daylight this can be achieved with reflectors. In daylight this form of back lighting can be secured with a dark background placed in front of the window, as shown in the sketch, with a small hole cut in it allowing a beam of light to strike in behind the figure.

In both (5) and (6) it is a good plan at times to use a reflector with a hole cut in it through which the photograph is taken. This not only allows a direct front reflection on to the sitter, but acts also as a lens shade to screen the lens from the direct rays of light coming from immediately in front, and which might tend to fog the film or plate.

This represents the six main arrangements of lighting to give definitely different effects, and to form the basis for the student who wishes to experiment in portraiture either by daylight or by artificial light.

By working in an ordinary room, without a special background, many pleasing varieties of "at home" portraits may be made, showing the sitter in his own usual surroundings. Care must be taken in such cases to avoid conflicting elements, such as pictures, unnecessary furniture, ornaments in the background that may catch the light, and so forth. The aim

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should always be to make the sitter the main centre of interest, and to keep the background and surroundings simple even if this means some re-arrangement of the furniture.

For normal portraiture the camera should be at the level of the eyes, although in the case of short people a lower viewpoint will add dignity, whilst for very tall people a higher viewpoint may be employed. The face should be carefully studied before the portrait is taken, so that a characteristic expression or attitude may be obtained. The eyes should follow the direction of the face, so that if the head is turned away the eyes should be turned in the same direction, and not back to the camera, unless a particularly coy or sly expression is being sought.

In all portrait work the question of exposure is vitally important. Tables purporting to give the exposures needed when working indoors by daylight would be only misleading, for the possible variations in conditions are too great. Only a photo-electric meter or extensive experience will help here. But in work by artificial light it is possible to describe and tabulate the conditions with high precision. Accurate exposure tables, therefore, can readily be constructed. Those that follow are adapted from a set published in *Amateur Photographer*, and can be fully relied upon.

Exposure Tables for Artificial Light.

The following tables apply to gas-filled pearl lamps in reflectors, placed so as to give a more or less frontal lighting of the subject. Shadows of normal depth are allowed for, the assumption being that the subject is in a fairly light room not too far from the wall. If this condition does not hold, either a reflector should be used or extra exposure given to allow for the absence of reflected light in the shadows.

The factors allowed for in the tables are speed of film wattage of light, distance of light from subject, angle of light ing, and lens-aperture. To calculate an exposure, appropriate numbers are taken from the various tables and added together Opposite the total in Table VI is found the exposure required.

Example.—A portrait is to be taken on a panchromatic film of speed 64 A.S.A. by the light of two Photoflood lamps placed at 5 feet from the sitter. Stop to be used $f/4{\cdot}5$. From Table I the film has the factor 12. From Table II two Photofloods (or 1600 watts) have factor 2, making the total (12 + 2) up to 14. The distance, 5 feet (Table III) adds 9, bringing the

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total (14 + 9) up to 23. The stop (Table V) adds a further 7, making the total now (23 + 7) = 30. Reference to Table VI shows that the required exposure is $\frac{1}{15}$ sec.

Non-Standard Lights. If opal lamps are used instead of pearl, add 1 to the total before using Table VI. If reflectors are not used, add an extra 2 to the total, and if diffusers are put in front of the lamp, add still a further 1 or 2, according to the amount of light they obstruct. An incandescent gas burner is about equivalent to a 50-watt electric lamp (Factor 12).

Several Lamps at Different Distances. For this case strict accuracy requires that the contribution made by each lamp to the total illumination be worked out, and the exposure then deduced from their sum. In practice it is sufficient to

TABLE I.—FILM SPEEDS

RATED SPEED.			FACTOR.	
DIN	B.S.	A.S.A.	Ortho Film.	Pan Film.
34	47	4,000	2	0
31	44	2,000	4	2
28	41	1,000	6	4
25	38	500	8	6
22	35	250	10	8
19	32	125	12	10
16	29	64	14	12
13	26	32	16	14
10	23	16	18	16
7	20	8	20	18

work out the exposure for the main light and either ignore the rest, or make such small correction for them as common sense may suggest. The main light for this purpose is not necessarily the bulb of highest power, but that for which the figures from Tables II and III (and Table IV if the light comes very much from side or top) add up to the smallest total. If two lights give the same total, it will be correct to give half the exposure calculated for either alone.

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TABLE II.—LIGHT INTENSITY

WATTS.	FACTOR.
100	10
150	9
200	8
300	7
400	6
600	5
800	4
1200	3
1600	2
2400	1
3200	0

Each No. 1 Photoflood should be reckoned as 600 watts, each No. 2 Photoflood as 1200 watts, and each studio lamp (500-w, 100 hr.) as 800 watts.

TABLE III.—DISTANCE OF LIGHT

FEET.	FACTOR.	FEET.	FACTOR.	FEET.	FACTOR.
1	0	$3\frac{1}{2}$	7	11	14
$1\frac{1}{4}$	1	4	8	$13\frac{1}{2}$	15
$1\frac{1}{2}$	2	$4\frac{3}{4}$	9	16	16
$1\frac{3}{4}$	3	6	10	19	17
2	4	$6\frac{3}{4}$	11	22	18
$2\frac{1}{2}$	5	8	12	27	19
3	6	$9\frac{1}{2}$	13	32	20

TABLE IV.—ANGLE OF MAIN LIGHTING

ANGLE.	FACTOR.
Up to 45 degrees	0
45 to 50 degrees	1
50 to 60 degrees	2
60 to 70 degrees	4
70 to 80 degrees	6

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Positive

TABLE V.—STOPS

STOPS.	FACTOR.	STOPS.	FACTOR.
f/1·4	0	*f*/4·8	7
f/1·6	1	*f*/5·6	8
f/2	2	*f*/6·7	9
f/2·4	3	*f*/8	10
f/2·8	4	*f*/9·6	11
f/3·2	5	*f*/11	12
f/4	6	*f*/14 (Most Box Cameras)	13

TABLE VI.—EXPOSURES

TOTAL.	EXPOSURE.	TOTAL.	EXPOSURE.
18	1/1000	33	1/6
19	1/700	34	1/4
20	1/500	35	1/3
21	1/350	36	1/2
22	1/250	37	3/4
23	1/175	38	1
24	1/120	39	1½
25	1/100	40	2
26	1/60	41	3
27	1/40	42	4
28	1/30	43	6
29	1/20	44	8
30	1/16	45	12
31	1/10	46	16
32	1/8	47	24

Positive. The familiar photograph, whether on paper or glass. So called to distinguish it from a negative, in which lights and shades are reversed. A diapositive is a positive on a transparent support, and an ordinary print on paper, for viewing by reflected light, has sometimes been called a katapositive.

Posterization. See TONE SEPARATION.

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Potash Alum. See ALUM.

Potassium Bichromate (Fr., *Bichromate de potasse, Chromate rouge de potassium ;* Ital., *Bicromata di potassa ;* Ger., *Kaliumdichromat*). $K_2Cr_2O_7 = 294$. Synonyms: Potassium Dichromate, Red Chromate of Potash, Acid Chromate of Potash. Is prepared on a large scale from chrome iron ore. It is met with commercially as fine orange-red crystals, which give a very deep-coloured solution. Solubility, 5 to 7 per cent. in cold, 100 per cent., in hot water; insoluble in alcohol. It is of great importance commercially, the fact of its being decomposed by light when in contact with organic matter being taken advantage of. It is used in photography in the chromium intensifier; to reduce contrast in bromide printing, in reversing solutions for colour or reversible cine films; in bleachers for various purposes; it sensitises colloids to light, and so is used in the carbon, gum, and allied processes, and also in photo-mechanical work. It is also used in cleaning mixtures.

A 10 per cent. solution is often referred to in photographic literature. This will deposit crystals at any temperature below about 62° F. Replace it, therefore, with a 5 per cent. solution, taking twice as much of it. (See also CARBON, OIL-PIGMENT, BROMOIL, GUM-BICHROMATE, and PHOTO-MECHANICAL PRINTING PROCESSES.)

Potassium Bromide (Fr., *Bromure de potasse ;* Ital., *Bromuro di potassio ;* Ger., *Bromkalium, Kaliumbromid*). $KBr = 119$. Solubility, about 35 per cent. in cold, 102 per cent. in hot water. It is used chiefly as a restrainer in developers, but also in bleachers to form silver bromide. In developers, it prevents fog and reduces grain size, but cuts down the effective speed of the emulsion. Excess of bromide in developers for black-tone papers gives greenish-blacks; with warm-tone papers bromide helps towards warmth of tone. (See DEVELOPMENT.)

Potassium Carbonate (Fr., *Carbonate de potasse ;* Ital., *Carbonato di potassa ;* Ger., *Kaliumcarbonat, Kohlensaures Kali, Potasche*). $K_2CO_3,3H_2O = 192$. Synonyms: Pearlash, Subcarbonate of Potash, Salt of Tartar, Salt of Wormwood, Potash. It contains nearly always about 16 per cent. of water. Solubility, about 80 per cent. in cold water; insoluble in alcohol and ether. It is extremely deliquescent—that is, absorbing moisture from the air—and becomes a

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pasty mass. It is used occasionally as an alkali in developers, and for dehydrating alcohol used for drying negatives or prints. Except perhaps with glycin, it is little used in modern developers ; it gives, however, rather higher alkalinity than does sodium carbonate. A mixture of 9 parts sodium carbonate with 1 part of caustic soda has been suggested as a substitute for it. (See DEVELOPMENT.)

Potassium Citrate. (Fr. *Citrate de potasse ;* Ital. *Citrato di potassio ;* Ger. *Kaliumcitrat ; Citronensaures Kali*) $K_3C_6H_5O_7 \cdot H_2O = 324$. Colourless crystals, very deliquescent, but keeping well in solid form if protected from moisture. Solutions soon grow moulds. Very soluble. Used in some toning solutions, especially those for copper toning, and in mordanting baths for dye toning.

Potassium Cyanide (Fr., *Cyanure de potasse ;* Ital., *Cianuro di potassio ;* Ger., *Cyankalium, Kaliumcyanid*). KCN or KCy = 65. Synonyms : Cyanide of Potash, "Cyanide." Obtained by fusing potassium ferrocyanide with potassium carbonate. The resulting fluid mass is poured out on slabs, and then broken up into the irregular masses met with in commerce. Solubility, 1 in 1 of cold, 122 per cent. in hot water ; 1·2 per cent. in absolute alcohol ; more soluble in dilute alcohol. It is used for reducing the density of negatives, and for fixing in the wet process. It is extremely poisonous when taken internally, and also when absorbed through the skin, or by any cut or abrasion. The addition of an acid immediately causes the evolution of hydrocyanic or prussic acid, which is extremely poisonous, and when inhaled, even in small quantities, produces vertigo and headache. (See POISONS.)

Potassium Ferricyanide (Fr., *Ferricyanure de potassium, Cyanoferride de potassium, Prussiate rouge de potassium ;* Ital., *Cianuro rosso di potassio e di ferro, Prussiato rosso di potassio ;* Ger., *Rotes Blutlaugensalz, Kaliumferricyanid*). $K_3Fe(CN)_6 = 329$. Synonyms : Ferridcyanide of Potash; Red Prussiate of Potash. Made by the action of chlorine gas on potassium ferrocyanide. Solubility, 36 per cent. in cold, 77·6 per cent. in hot water ; insoluble in absolute alcohol ; more soluble in dilute alcohol. It is met with as deep red crystals, that become covered with a yellowish powder, which should be removed by rinsing with water before use. It keeps well in solid form ; solutions should be protected from light and not allowed to come into contact with a cork unless it is waxed.

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Used in Farmer's reducer, and in bleachers and toning baths. Also in cyanotype printing. Ferricyanides are generally considered to be non-poisonous, but no liberties should be taken. Solutions and solid are perfectly safe to handle for all photographic purposes.

Note that the yellow potassium ferrocyanide, quite useless as a substitute for ferricyanide, is sometimes accidentally supplied in its place. (See REDUCTION, OF DENSITY, and TONING.)

Potassium Hydroxide (Fr., *Potasse caustique ;* Ger., *Aetzkali*). Synonyms: Caustic potash, Potassium hydrate KOH=56. White lumps, flakes, sticks, or pellets, the two latter usually being the purest. Deliquescent, and becomes superficially converted to carbonate on exposure to air. Keep, therefore, in bottle sealed with wax. Solubility, 75 per cent. in cold water. Used occasionally as an alkali in developers, particularly concentrated paraminophenol, where in conjunction with potassium metabisulphite it makes potassium sulphite, preferred to sodium sulphite on account of its greater solubility.

Potassium Iodide (Fr., *Iodure de potassium ;* Ital., *Ioduro di potassio ;* Ger., *Jodkalium, Kaliumiodid*). KI=166. Prepared by dissolving iodine in hot solution of caustic potash, evaporating and fusing the crystalline mass with charcoal and subsequent lixiviation. Solubility, 138 per cent. in cold, 208 per cent. in hot water ; 1·5 per cent. in alcohol, 0·12 per cent. in ether ; 0·8 per cent. in alcohol and ether ; 40 per cent. in glycerine. It is used for iodising collodion, in emulsion-making, as an ingredient of some intensifiers, and in the fore-bath used in physical development.

Potassium Metabisulphite (Fr., *Métabisulfite de potassium, Bisulfite,* or *Sulfite acide de potasse ;* Ital., *Metabisolfito di potassa ;* Ger., *Kaliummetabisulfit*). $K_2S_2O_5=222$. Prepared by saturating a solution of potassium carbonate with sulphur dioxide and precipitating the metabisulphite with alcohol. Solubility, 1 : 3 of water, insoluble in alcohol. It is used as a preservative of pyrogallol, but its chief importance is as an addition to the fixing bath to make it acid and prevent staining. May be used to replace sodium bisulphite or sodium bisulphite lye (see these entries) in all their usual applications : 107 parts replace 100 parts by weight of sodium bisulphite, or 205 parts by volume of the lye.

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Potassium Oxalate (Fr., *Oxalate neutre de potassium ;* Ital., *Ossalato neutro di potassa ;* Ger., *Oxalsaures Kali, Kaliumoxalat*). $K_2C_2O_4H_2O = 184$. Synonym ; Neutral Oxalate of Potash. Prepared by neutralising oxalic acid with potassium carbonate or caustic potash. Solubility, 1 in 3 of water ; insoluble in alcohol or ether. It is used for the production of ferrous oxalate, and as a developer in the platinotype process. This salt should not be confounded with the binoxalate or acid potassium oxalate known commercially as salt of sorrel.

Potassium Permanganate (Fr., *Permanganate de potasse ;* Ital., *Permanganato di potassa ;* Ger., *Uebermangansaures Kali, Kaliumpermanganat*). $KMnO_4 = 158$. Small purple-black lustrous crystals, giving pink or deep purple solution. Powerful oxidising agent ; decolourised by reducing agents, including bisulphite and hypo. Solubility, about 3 per cent. in cold water. Used as bleacher and stain-remover, as reducer, in reversing bath for cine and colour films. Also as a test for hypo and as a hypo-eliminator. In view of its diverse uses, it is best kept as a $2\frac{1}{2}$ per cent. stock solution (40 c.c. = 1 gm., or 1 oz. = 11 grains). Each 10 parts may be replaced by 9 parts of the very deliquescent and much more soluble sodium permanganate.

Potassium Sulphide (Fr., *Foie de soufre, Trisulfure de potassium ;* Ital., *Pentasulfuro di potassio ;* Ger., *Schwefelkalium, Kaliumsulfid, Schwefelleber*). Synonyms : Liver of Sulphur, Sulphuretted Potash, Potassium Trisulphide. A substance of variable composition, but consisting mainly of potassium trisulphide K_2S_3 and potassium thiosulphate $K_2S_2O_3$. Solubility : partially soluble in water, and three-quarters of it by weight soluble in alcohol. It is used for the reduction of residues, and occasionally also for toning.

Potassium Thiocyanate. (Fr. *Sulphocyanure de potasse ;* Ital. *Rodanuro* or *Solfocianuro di potassio ;* Ger. *Rhodankalium* or *Kaliumrhodanat.*) KCNS = 97. Synonyms : potassium sulphocyanide, potassium sulphocyanate. White watery crystals, extremely deliquescent, but keeping well in bottle with waxed-in cork, or as a stock solution. Solubility about 60 per cent. in cold water. Used in fine-grain developers as a solvent of silver bromide, and also in gold toning baths and in mordanting baths for dye toning.

Powder Process, or Dusting-on Process. A thin coating of sugar, albumen and bichromate is exposed to daylight under a positive transparency. The coating, initially tacky, harden-

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on exposure to light. If powdered graphite or other material is now dusted on, it will adhere only to the parts protected during exposure, so reproducing the transparency from which it was made. See also HYALOGRAPHY, PHOTOGRAPHIC, and PEPPERTYPE.

Preservative. Name applied to a chemical used in a developing or other solution to preserve it from too rapid oxidation. The usual preservative is sodium sulphite, but potassium metabisulphite, citric acid, and one or two other substances are also occasionally used. Oil of wintergreen (methyl salicylate), often used in paste mountants to prevent bacterial action, is also called a preservative.

Press Camera. See CAMERA.

Press Photography. This term is usually applied to the photography, for daily or weekly journals, of subjects having news or topical interest. Although the illustrated papers and agencies employ their own press photographers, every amateur has an opportunity of turning his camera pictures—provided they are of the right type of interest—into cash, by carefully placing his photographs in the right market. The subject is too extensive for adequate treatment in a dictionary article, and the reader is referred to the several books on this subject, and in addition to the "Writer's and Artist's Year Book," an annual publication which contains a list of every magazine and newspaper, with the special wants of each, together with the addresses of editorial offices and press agencies.

Primuline Process. See DIAZOTYPE PROCESS.

Principal Axis is the straight line which joins the centres of curvature of the spherical surfaces of a lens, or if one surface is plane, the principal axis passes through the centre of curvature of the spherical surface, and is perpendicular to the plane surface. A straight line passing through the optical centre, and making an angle with the principal axis, is termed a secondary axis. The centres of curvature are the centres of spheres, of which spheres the surfaces of the lens are segments. (See LENS.)

Print-Finishing. To finish in black and white and colour, see ENLARGING and BROMIDE PAPER; see also AIR BRUSH, SPOTTING PRINTS and COLOURING PHOTOGRAPHS.

Print Trimming. See TRIMMING.

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Printing. This term is applied to any process by means of which a positive impression is made from a negative. Until recently the term, used without qualification, always meant the production, upon paper, of a positive identical in size with the negative (*i.e.* a contact print) but with the wider adoption of cameras making such small negatives that practically all are printed by projection, it has come to include the production of enlargements. Contact printing by daylight is now practically obsolete. The vast majority of contact prints are now made on contact paper, while enlargements are always made either on bromide or chloro-bromide paper.

The following table, adapted from Clerc's *Photography*, gives an approximate indication of the relative exposures required in different printing processes ; the comparative exposure for a fast negative emulsion is also included.

Contact paper	8 – 40 min.
Warm tone lantern-plates (according to tone) . . .	2½ – 40 min.
Chlorobromide papers . . .	12 – 24 sec.
Bromide papers	2 – 8 sec.
Black-tone lantern-plates . .	1 – 3 sec.
High-speed negative emulsions .	1/100 sec.

For details of the various processes, see BROMIDE PAPER, GELATINO-CHLORIDE PAPER, CARBON PROCESS, PLATINOTYPE, OIL-PIGMENT PROCESS, BROMOIL, GUM-BICHROMATE PROCESS, KALLITYPE, PALLADIOTYPE, SELF-TONING PAPER, COLLODIO-CHLORIDE PRINTING-OUT PAPER, CHLOROBROMIDE PAPERS, ALBUMEN PROCESS, PLAIN (SALTED) PAPERS, CYANOTYPE, CARBRO, OLEOBROM PROCESS, OZOTYPE, OZOBROME, LANTERN SLIDES, ENLARGING, etc.

Printing Box. A box containing an electric bulb and having a printing frame of suitable type built into its upper surface. Often an orange light is also mounted in the box. Negative and paper are laid on a glass in the frame, and adjusted with the aid of the orange light ; after closing the back of the frame, the print is exposed by switching on the white light for a suitable time. Printing boxes are particularly helpful as time-savers where many prints have to be made.

Printing Frame. A specially-made frame, generally of wood with deep rabbets, for holding negative and printing paper closely together while making a contact print. Most

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frames are fitted with hinged wooden backs, lined with baize, and held down by flat springs. When using a printing-out process, one portion of the back may be lifted to observe the progress of printing without disturbing the print.

Printing In. See COMBINATION PRINTING.

Printing Surfaces and Blocks. See PHOTO-MECHANICAL PRINTING PROCESSES.

Printing Up. Term used when extra exposure is given, during enlarging, to a part of a picture that prints too light.

Prism. See SPECTROSCOPE.

Prism, Reversing. A right-angled reflecting prism placed over the lens of the camera to obtain negatives reversed from left to right. Used in several of the photo-mechanical processes. (See REVERSED NEGATIVE.)

Process Blocks. See PHOTO-MECHANICAL PRINTING PROCESSES.

Projection Lamps. For all normal purposes of projection whether in a lantern, an enlarger, or a cine-projector, electric lamps are now universally used.

A lamp designed for projection has an especially compact filament, approximating as nearly as possible to the point source theoretically required. When the highest efficiency is required a low-voltage lamp is chosen, as the thicker filament of a low-voltage lamp can be brought to a higher temperature, so enhancing the luminous efficiency. Further, adjacent parts of the filament can be brought closer without risk of arcing, so reducing the luminous area and increasing the efficiency of the optical system. On the alternating-current mains now almost universal, the use of a low voltage lamp leads to no appreciable wastage of electrical power provided that a transformer is interposed between mains and lamp ; on direct-current mains, on the other hand, so much energy would be wasted in the resistance needed to reduce the voltage that a high-voltage lamp is nearly always preferred.

Projection lamps are normally over-run to a certain extent to increase the light output, the main advantage of this being not economy, but a reduction of the heat developed in the lamp. Their life may be taken as averaging 100 hours in most patterns. As an over-run lamp is particularly sensitive to further over-running, it is wise to place a volt-meter across the lamp, and to supply a small variable resistance that can

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be adjusted to compensate for variations in the voltage of the mains.

The resistance of a lamp filament is many times lower when cold than when hot, so that on first switching on a very heavy current passes through the filament. This sets up heavy magnetic fields that suddenly pull adjacent legs of the filament together or force them apart, and if the filament is brittle these stresses may cause it to fracture. All this can be prevented by connecting in series with the lamp a Brimistor, a simple electrical component costing only a few shillings, which offers high resistance when cold and very low resistance when hot. On switching on with a Brimistor in series, the lamp takes a second or two to reach full brilliance, when the Brimistor can be switched out of circuit by a shorting switch across it. If left in circuit the loss of brilliance is trifling, but the Brimistor gets very hot and must be isolated from anything that could be damaged by heat.

A concave reflector is normally used to return to the condenser light emitted from the back of the filament. This should be adjusted so that the images of successive legs of the filament are formed in the spaces between adjacent legs in the lamp itself. The whole then forms a practically continuous luminous surface. With correct adjustment, the reflector can increase the light reaching the condenser, and hence the screen, by some 70 per cent.

For the projection of amateur cine films, the frame of which is so small that there is difficulty in directing enough light through it from a projection lamp with a normal filament, it is now usual to employ a low-voltage lamp the inside of the bulb of which is silvered except for one small clear patch. The bulb is so shaped as to direct through this patch, by single or multiple reflection, a very high proportion indeed of the light emitted by the extremely compact filament. With 8-mm. films, such a lamp can direct through the tiny frame far more light per watt than can be had from a standard projection lamp. The projector as a whole, of course, keeps cooler; it is sometimes overlooked that the film does not.

Projection Printing. The making of prints by any means involving the projection upon the printing paper (plate, film, etc.) of an image of the negative, a lens being used to form this image. Normally, this is done by an enlarger (see ENLARGING), though the use of other related apparatus, such as an

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episcope for the projection of paper negatives, would also be included as " projection printing."

Projector. An apparatus used to project a magnified image of a positive upon a white screen in a darkened room. Projectors are of three main types; those for ciné films (see CINEMATOGRAPHY), those for standard lantern slides 3¼ in. square, and the extremely popular miniature projectors for slides of overall size 2 in. square, bearing pictures usually 24 × 36 mm. in size. This latter type can also in some cases be adapted for taking 35-mm. cine film in the length, and is very widely used for projecting colour transparencies, which are returned from the processing station either mounted as slides or in 20- or 36-exposure lengths. Projectors for slides 2¼ in. sq. are still comparatively rare.

A projector for still pictures consists of a metal lamphouse in which is placed a projector lamp. Behind it there is a concave mirror, in front of it a condenser and a piece of heat-absorbing glass (" heat-filter ") to protect the transparency from overheating. The condenser usually consists of two lenses, one plano-convex and the other with one aspherical surface (*q.v.*). In front of this again is a carrier for the transparency, with means for changing one transparency quickly for another. The traditional carrier consists of a pull-through slide taking one transparency at each end; while one is being projected the other is replaced by a fresh one. A high-quality lens—nowadays often an anastigmat—of aperture *f*/2·8 or thereabouts is used to project on the screen an image of the brilliantly illuminated transparency.

According to British Standard No. 1915 (1952) the lens shall be such that at the centre of the frame not less than 56 lines per millimetre shall be resolved; without refocusing, resolution shall not fall below 14 lines per millimetre at the corners of a 24 × 36 mm. transparency. The light output of the projector shall not fall below 100 lumens, and the illumination at the corners of the projected picture shall not fall below half that at the centre.

Projectors, especially those for 2 × 2 in. slides, have recently been very greatly elaborated and improved. In all but the cheaper models some automatic or semi-automatic device is used, in place of the simple push-pull carrier, to change the transparencies. The most favoured method employs a magazine, usually of plastic, holding 30 or 36 transparencies in grooved slots. Operation is by a sliding arm,

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which when pushed in brings a fresh transparency into the gate of the projector, and when pulled out again returns the preceding one to the magazine and at the same time advances the magazine one step. When all the transparencies have been shown, the magazine is withdrawn, with all the transparencies in their original positions in it, and replaced by a fresh magazine. In most cases the magazines have lids so that they can conveniently be used as storage boxes.

Another plan involves the use of a tray or chute on which the transparencies are placed and held in a tight pack by a spring-loaded pressure plate. A push-through arm picks up one transparency and pushes it into the gate, at the same time pushing the previous one out into a similar tray on the other side of the projector. Since more transparencies can be added to the pack before it is exhausted, this method avoids the break in projection involved in changing magazines, but does not automatically provide storage.

In still more advanced projectors there is an electric motor to work the changing mechanism, so that pressing a button on the projector, or on the end of an extension-cord of any desired length, operates the change. This allows the operator to join the audience, or to stand by the screen to give a commentary. It is usual for models so fitted also to have remotely controlled focusing to allow for differences in register of successive slides.

The following approximate rules will be useful for finding the length of the projected picture at different distances from the screen, or for choosing a lens to give a picture of predetermined size:—

If distance from projecting lens to screen is D
Length (or diameter) of picture on slide is d_1
Length (or diameter) of projected picture is d_2,
Focal length of lens is f.

$$\text{Then} \quad d_2 = \frac{D}{f} \times d_1 \quad . \quad . \quad . \quad . \quad (1)$$

$$D = \frac{d_2}{d_1} \times f \quad . \quad . \quad . \quad . \quad (2)$$

$$f = \frac{D}{d_2} \times d_1 \quad . \quad . \quad . \quad . \quad (3)$$

Table I (page 542) gives the size of the projected picture at different distances with lenses of different focal lengths. Table II (page 543) gives similar details for miniature projectors.

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Simple Lens for Projection. Where the highest definition is not required on the screen, a lens for projection may be assembled as follows (L. Lumière). To obtain a lens of focal length F, two plano-convex lenses of focal length $1\frac{1}{3}$ F. are mounted with their curved surfaces facing one another and their plane surfaces separated by a distance $\frac{5}{9}$ F. If, for example a 9-inch lens is required, obtain two lenses each of focal length 12 in., and mount them at the ends of a tube 8 in. long. If the lenses are 2 in. in diameter, the completed projection-lens will work at $f/4.5$. In fitting this lens to a lantern, it must be be remembered that the calculated lens-to-slide distances (see CONJUGATE FOCI) will in this case include nearly three-quarters of the overall length of the lens. The diameter of each lens must be not less than two-thirds of the diagonal of the slide to be projected.

Screens for Projection.—For all ordinary purposes a plain white screen is best, but it should be noted that it ought to be not only white, but also opaque, so that no light may be lost by transmission. For a small screen white card is perfectly satisfactory, and in larger sizes a wooden framework covered with a stout white cloth may be used. The cloth may be painted over with whitewash into which has been mixed a proportion of size to prevent it from flaking off. The following mixture, however, is even better.

Gum arabic	1 oz.	(50 gm.)
White magnesia (hydrocarbonate)	4 oz.	(200 gm.)
Water, about . . .	20 oz.	(1000 c.c.)

Where the screen is to be rollable, a trace of glycerine may be added to render the coating more flexible.

Metallised Screens are useful, especially for cine-projection, when there is difficulty in obtaining a bright enough picture on an ordinary white screen. It should, however, be noted that metallised screens, of any type, are only suitable for a small audience clustered closely about the line joining screen and projector. A suitable coating is made by mixing in 20 oz. (1000 c.c.) of water, slightly warmed in a water-bath,

Slaked lime	260 gr.	(30 gm.)
Casein	300 gr.	(35 gm.)
Sodium silicate . . .	90 gr.	(10 gm.)

To this add 175 gr. (20 gm.) of whitening, and 175 gr. (20 gm.) of impalpable aluminium powder. This should

TABLE I.—SCREEN DISTANCES FOR STANDARD LANTERNS.

Distance between Lantern and Screen	FOCUS OF LENS.																					
	4 in.		5 in.		6 in.		7 in.		8 in.		9 in.		10 in.		11 in.		12 in.		13 in.		14 in.	
	DIAMETER OF DISC FROM 3-in. CIRCLE ON SLIDE.																					
	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
10 ft. . .	7	6	6	0	5	0	4	3	3	9	3	4	3	0	2	9	2	6	2	4	2	2
11 ft. . .	8	3	6	7	5	6	4	9	4	2	3	8	3	4	3	0	2	9	2	6	2	4
12 ft. . .	9	0	7	2	6	0	5	2	4	6	4	0	3	7	3	3	3	0	2	9	2	7
13 ft. . .	9	9	7	10	6	6	5	7	4	11	4	4	3	11	3	7	3	3	3	0	2	9
14 ft. . .	10	6	8	5	7	0	6	0	5	3	4	8	4	2	3	10	3	7	3	3	3	0
15 ft. . .	11	3	9	0	7	6	6	5	5	8	5	0	4	6	4	1	3	9	3	6	3	3
20 ft. . .	15	0	12	0	10	0	8	7	7	6	6	8	6	0	5	6	5	0	4	7	4	3
25 ft. . .	18	9	15	0	12	6	10	9	9	4	8	4	7	6	6	10	6	3	5	9	5	4
30 ft. . .	22	6	18	0	15	0	12	10	11	3	10	0	9	0	8	2	7	6	6	11	6	5
35 ft. . .	26	3	21	0	17	6	15	0	13	1	11	8	10	6	9	6	8	9	8	1	7	6
40 ft. . .	30	0	24	0	20	0	17	2	15	0	13	4	12	0	10	10	10	0	9	2	8	6
45 ft. . .	33	9	27	0	22	6	19	3	16	10	15	0	13	6	12	3	11	3	10	4	9	8
50 ft. . .	37	6	30	0	25	0	21	5	18	9	16	8	15	0	13	8	12	6	11	6	10	6

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TABLE II.—SCREEN DISTANCES FOR MINIATURE PROJECTORS.

Distance from Projector to Screen	FOCAL LENGTH OF PROJECTOR LENS.								
	3.5 / 1⅜	5 / 2	6 / 2⅜	7.5 / 3	9 / 3½	10.5 / 4⅛	12 / 4¾	13.5 / 5¼	15 cm. / 6 in.
	LENGTH OF PROJECTED PICTURE FROM 24 × 36 mm. SLIDE.								
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
5 ft. . . .	5 0	3 6	2 11	2 3	1 11	1 7	1 5	1 3	1 1
6 ft. . . .	6 0	4 2	3 6	2 9	2 3	1 11	1 8	1 6	1 4
7 ft. . . .	7 1	4 11	4 1	3 3	2 8	2 3	2 0	1 9	1 7
8 ft. . . .	8 1	5 8	4 8	3 9	3 1	2 7	2 3	2 0	1 10
9 ft. . . .	9 1	6 4	5 3	4 2	3 6	3 0	2 7	2 3	2 0
10 ft. . . .	10 2	7 1	5 11	4 8	3 11	3 4	2 11	2 6	2 3
12 ft. . . .	12 2	8 6	7 1	5 8	4 8	4 0	3 6	3 1	2 9
14 ft. . . .	14 3	9 11	8 3	6 7	5 6	4 8	4 1	3 7	3 3
16 ft. . . .	16 4	1 5	9 6	7 7	6 3	5 4	4 8	4 2	3 9
20 ft. . . .	20 5	14 3	11 11	9 6	7 11	6 9	5 11	5 3	4 8
25 ft. . . .	25 7	17 11	14 11	11 11	9 11	8 5	7 5	6 7	5 11
30 ft. . . .	30 9	21 6	17 11	14 3	11 11	10 2	8 11	7 10	7 1
40 ft. . . .	41 0	28 8	23 11	19 1	15 11	13 7	11 11	10 6	9 6

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preferably be sprayed on to the screen. A metallised screen is essential for stereoscopic projection, as it does not depolarise light; a plain matt screen does.

Proportional Reducer. Reducer which reduces contrast without changing the density-ratios of the negative to which it is applied. Reduction thus takes place without falsification of the gradation of tones. For formulæ and details, see REDUCTION (OF DENSITY).

Push Pins. Convenient steel pins with large glass, metal or wood heads. Used for pinning up prints or films to dry, or for fixing bromide paper on to enlarging easel when making enlargements.

P.V. (Panchromatic Vision) Filter. A filter prepared by Ilford Ltd., for viewing the subject to see how it will be rendered in monochrome. Used alone, a P.V. filter shows the subject as it will be reproduced on a panchromatic emulsion without colour-filter; by holding over it the yellow, green, or other filter it is proposed to use, the subject is seen as it will appear when photographed through the colour-filter.

Pyro. See PYROGALLOL.

Pyro-Ammonia and **Pyro-Soda.** See DEVELOPMENT.

Pyrocatechin. (Fr. *Pyrocatéchine;* Ger. *Brenzkatechin*) 1—2 $C_6H_4(OH)_2 = 110$. Synonyms: Catechol; Pyrocatechol. Chemical name, orthodihydroxy-benzene; an isomer of hydroquinone. Colourless crystals with decided "medicinal" smell. Developing agent of moderate activity, Watkins factor 8 to 10. For satisfactory development, its solutions require a *p*H of not less than 8·7. Solubility about 40 per cent. in cold water. Notable for its tanning action on the gelatine containing the developed image, which is usually of a warm colour, due to stain. Solutions quickly take on a reddish colour, even when fresh. Pyrocatechin is particularly suited to the preparation of concentrated two-solution formulæ, and is said to compensate for over-exposure. Crystallized with its own weight of para-phenylene diamine, forms Meritol (*q.v.*); except in this form, is but little used in England, though often met in formulæ of German origin. (See DEVELOPMENT; also MERITOL.)

Pyrogallol (Fr., *Acide pyrogallique;* Ger., *Pyrogallol, Pyrogallussäure*). Synonym: Pyrogallic acid, but is universally known as "pyro." 1-2-3 trihydroxybenzene

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$C_6H_3(OH)_3 = 126$. The oldest of all the developing agents (introduced 1851). It is particularly suited to development by inspection. Occurs as white crystals or in the purer re-sublimed form ; soluble in water to extent of some 40 per cent., and dissolves also in alcohol and ether. Inclined to stain the fingers, and unless much sulphite is used gives yellow or brown dye-image reinforcing the silver image. This is no disadvantage, but pyro-developed negatives are stronger than they appear. Generally used nowadays with sodium carbonate (pyro-soda developer) but develops maximum energy with caustic alkali in amount sufficient to form monophenolate ($NaO\text{-}C_6H_3(OH)_2$). With more alkali it gives intense chemical fog. Maximum amounts of caustic alkalies : 45 parts of caustic potash or 32 parts of caustic soda per 100 parts of pyro. (See also DEVELOPMENT.)

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Q

Quick Drying of Negatives and Prints. See DRYING NEGATIVES.

Quick-Fire Cameras. Cameras equipped with special mechanism for winding on the film and resetting the shutter practically instantaneously, so allowing exposures to follow one another very rapidly when required. In one camera at least these movements are automatically performed by a clockwork motor the moment the finger is lifted from the shutter-release after making the exposure; in another, an electric motor, powered by batteries, is used. Quick-fire cameras generally use 35-mm. cine film as negative material.

Quick Processing. See RAPID PROCESSING.

Quinol. An alternative name for hydroquinone (*q.v.*).

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R

Rack and Pinion Focusing. A type of focusing movement in which separation between lens and plate is controlled by turning a knob mounted on the same spindle as a pinion, or small toothed wheel. Rotation of this moves a rack in the form of a straight row of teeth on a metal plate, so moving this forward or back and altering the distance between lens and sensitive surface. (See FOCUSING.)

Radiography. The photography by means of X-rays of bones, muscles and other organs of the body. No camera is used, but the part of the body to be photographed is interposed between a plate or film (enclosed in a black envelope) and the X-ray tube. The picture made is thus always a shadowgraph. Exposures of a fraction of a second can be given with the most modern apparatus. A heavily-coated plate is desirable, but so much of the X-rays penetrate even the most heavily-coated emulsion that exposures are long. To avoid this, " intensifying screens " are used. These consist of a layer of fluorescent material laid in contact with the plate or film, which is acted upon more by the light emitted by the screen as the X-rays fall upon it than by the X-rays themselves.

Range-Finder. Optical device for measuring the distance of an object from the observer, and of use to the photographer in enabling him to focus his camera accurately on the required object. The principle involved is that of sighting the object from two adjacent points, and estimating the distance by observing the angle between the two lines of sight converging upon the object from these two points.

In the " tilting mirror " range-finder the object is viewed directly through one window, and a half-silvered mirror is placed across the line of sight at an angle of 45°. Light which

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enters the range-finder from the second window is deflected on to this half-silvered mirror, and so to the eye, by means of a second mirror (or reflecting prism). This second mirror can be turned through a small angle so as to bring direct and reflected images into coincidence, and the knob or disc that controls this movement is graduated in distances.

The " rotating wedge " range-finder (Zeiss) is similar in structure, but in this the second mirror is permanently fixed. In front of one window a rotating wedge is used to deflect light reaching the window from the object, so that again the two images are superposed to ascertain the distance. The rotating wedge consists of two circular glass wedges or prisms rotating in opposite directions, this being necessary to avoid deflection of the image in a direction at right angles to that joining the windows of the rangefinder.

The " swing wedge " range-finder (Zeiss) is similar in principle to the rotating wedge, but simpler. Here the wedge consists of a plano-convex and a plano-concave cylindrical lens, with their curved surfaces in contact. Slight sideways movement (at right-angles to the axis of the cylinder of which the curved surfaces form part) upsets the parallelism of the plane surfaces and enables the whole to behave as a wedge or prism of variable angle.

In any of these forms the range-finder can be used as a separate instrument, or alternatively its movement can be mechanically coupled to the focusing movement of the lens, so that the act of measuring the distance simultaneously focuses the camera. In this case the range-finder is built into the camera, and is known as a *coupled range-finder*.

There is also a focusing aid, often referred to as a range-finder, which is common in reflex cameras, especially the eye-level (pentaprism) miniature reflexes. It consists of two wedges, lying side by side, embedded in the ground surface of the focusing screen. When focus is correct, a line running across the junction of the wedges is continuous, but when it is incorrect one wedge diverts the image one way and the other diverts it in the opposite direction, so that the line appears broken. The device is operative only when the lens is at a wide aperture; at smaller apertures no image is seen and the wedges appear black. Since the " range-finder " is operated by the focused image, it will work with lenses of any focal length provided the aperture is wide enough, and needs no adaptation of any kind if one lens is exchanged for another.

See also MINIATURE CAMERAS.

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Rapid Processing. The following formulæ have been worked out for developing and fixing a negative in the shortest possible time.

Rapid Developer.

Hydroquinone	260 gr.	(30 gm.)
Sodium sulphite (anhydr.)	220 gr.	(25 gm.)
Phenosafranin (1 : 1000 solution)	190 min.	(20 c.c.)
Caustic potash	525 gr.	(60 gm.)
Water to	20 oz.	(1000 c.c.)

Development time, about 25 sec. at 68°–70° F.

Rapid Two-Bath Developer.

A.	Hydroquinone	440 gr.	(50 gm.)
	Sulphurous acid (5 to 10 per cent.)	4½ oz.	(230 c.c.)
	Phenosafranin (1 : 1000 solution)	190 min.	(20 c.c.)
	Water to	20 oz.	(1000 c.c.)
B.	Caustic Potash	6½ oz.	(300 gm.)
	Water to	20 oz.	(1000 c.c.)

Immerse in A at 77° for 5 seconds, and transfer to B, also at 77° F., for 2 seconds. Then transfer for 2 seconds to a stop-bath of 10 per cent. acetic acid, and fix.

Rapid Fixing Bath.—Ammonium thiosulphate fixes more rapidly than the sodium salt, so that fixing can be accelerated by adding ammonium chloride (sal-ammoniac) to ordinary hypo.

Hypo	4 oz.	(200 gm.)
Potassium metabisulphite	220 gr.	(25 gm.)
Ammonium chloride	350 gr.	(40 gm.)
Water to	20 oz.	(1000 c.c.)

Rapid fixers, based on ammonium thiosulphate, are available ready-prepared from several manufacturers.

Rapidity of Lenses. A fast or rapid lens is one the largest aperture of which is a considerable fraction of its focal length—*i.e.*, the *f*/number of its largest aperture is small. (See DIAPHRAGMS.) The fastest lenses in regular use for still photography at the present time work at about *f*/1·2, though one lens working at *f*/0·95 is available; owing to their price, such fast lenses are not very widely used. Lenses of aperture *f*/2 or *f*/1·8 are common on miniature cameras of the more expensive type, while lenses of aperture *f*/2·8 are freely fitted

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to small cameras sold at quite moderate prices. On cameras for pictures as large as $2\frac{1}{4} \times 2\frac{1}{4}$ in. lenses faster than $f/3{\cdot}5$ are not often used.

Rapid Rectilinear (R.R.), or Rapid Symmetrical Lens. See LENS.

Rayometer. A kind of actinometer (generally a screen of aluminium of graduated thickness) used in testing sensitiveness to X-rays. (See RADIOGRAPHY.)

Réaumur. See THERMOMETRY.

Reciprocity Law. The simple photometric law which states that the amount of light energy reaching a surface (photographically, the exposure) is given by the product of the illumination and the time it is allowed to act. Thus an exposure of 1 second to a 100 c.p. lamp allows the same amount of light energy to reach the sensitive surface as would a 100-second exposure to a 1 c.p. lamp at the same distance.

But the effect of these two equivalent exposures on the sensitive emulsion is not in practice found to be the same, for there is one particular intensity of light, differing from emulsion to emulsion, to which the film or plate is most sensitive. A ten-second exposure to light of this intensity thus affects the emulsion more than does either a one-second exposure to a light ten times brighter, or a 100-second exposure to a light only one-tenth as bright as that to which the material is most sensitive. This failure of the film to respond equally to exposures of equal energy, but made up of time and intensity in different proportions, is known as the "failure of the reciprocity law." (See also ELECTRONIC FLASH.)

Recordak. See COPYING.

Record Photography. Photography used purely for the purpose of making a record, with no pictorial intent. Usually contrasted with pictorial photography.

Red Prussiate of Potash. See POTASSIUM FERRICYANIDE.

Redevelopment. If the silver in a photographic image is converted into silver chloride or bromide, without at the same time adding anything to it, it can be redeveloped to its original intensity in any ordinary developer. A bleacher containing 1 part potassium ferricyanide and 1 part potassium bromide to 20 parts of water is suitable for either negatives or prints. In the case of a too-contrasty negative, development can be

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interrupted when it is deemed to have gone far enough, and the as yet undeveloped silver bromide fixed away in an ordinary hypo bath. (See HARMONISING HARSH NEGATIVES.) When a print is redeveloped, the object is usually to improve the colour, for it generally redevelops to a fairly pure black.

In wet-collodion work, the term "redevelopment" is often used for a process of intensification (*q.v.*).

Reducer. Solution used for the process of REDUCTION (*q.v.*). Such a solution always contains an oxidising agent (*e.g.*, ammonium persulphate) to which also the name "reducer" may be applied. (See REDUCING AGENT.)

Reducing Agent. Chemical substance capable of absorbing oxygen. Not to be confounded with "reducer" (in the photographic sense) which, by adding oxygen or its equivalent to the silver image, proceeds to dissolve it away. All developers contain a reducing agent such as pyro, metol, amidol, etc.

Reduction (in Size). The making of a lantern slide or print of smaller dimensions than the negative it is made from. A method of reduction is given under LANTERN SLIDES, and by substituting bromide paper for the lantern plate, the method is equally applicable to the making of prints. (See also MICRO-PHOTOGRAPHY.)

Reduction (of Density). This process consists of partially dissolving away the photographic image, an oxidising agent being used as the active chemical. Different reducers act in different ways, some tending to increase contrast by acting more vigorously on the weaker tones of the image, while others tend to decrease it by acting more vigorously on the stronger tones. Either of these actions tends to falsify tone-values; where reduction is resorted to as a corrective of simple over-development, a proportional reducer (*q.v.*) is required.

Innumerable formulæ for reducers have been put forward; the following is a selection of the more valuable of these.

Howard Farmer's Reducer.—This reducer, named after its inventor, tends to attack the fainter deposits most quickly, unless used very dilute. It is therefore valuable for treating a dense and foggy negative.

Make up a 10 per cent. solution of potassium ferricyanide, which keeps fairly well in the dark as a stock solution. To prepare the reducer, add 1 part of this stock solution to some 5 to 10 parts of 20 per cent. hypo solution. In this proportion

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fog and the fainter densities are rapidly attacked, and the negative should be withdrawn from the solution and washed under the tap just before the desired degree of reduction is attained.

If the amount of ferricyanide is cut down considerably, taking only 1 part of the stock solution to about 50 parts of 20 per cent. hypo, reduction is slower and the denser parts of the negative tend to be affected first, so reducing contrast. At the expiration of some 5 minutes the mixed solution should be discarded ; if further reduction is required a fresh mixture must be prepared. After reduction, the negative is washed and dried as usual.

Two-solution Farmer's reducer.—It is now quite common practice to keep ferricyanide and hypo in two separate solutions, and apply them to the negative in turn. If a hypo-free negative is immersed in a plain 1 per cent. solution of ferricyanide some slight bleaching takes place ; the bleached part of the image dissolves away when the negative is transferred to 10 per cent. hypo solution. Used in this way, the reducer is approximately proportional in its action.

If, however, the negative is first soaked in the hypo solution and then transferred to the ferricyanide, the reaction is much more rapid and the main effect is on the least dense (shadow) portions.

Belitzky's Reducer.—This reducer is particularly suitable for over-developed negatives, as it reduces contrast considerably and shadow detail but little. A modern formula (Kodak R8) is:—

Ferric chloride . . .	220 gr.	(25 gm.)
Potass. citrate . . .	1½ oz.	(75 gm.)
Sodium sulphite (anhydr.) .	260 gr.	(30 gm.)
Citric acid . . .	175 gr.	(20 gm.)
Hypo (cryst.) . . .	4 oz.	(200 gm.)
Water to . . .	20 oz.	(1000 c.c.)

May be used at full strength for rapid reduction, or diluted with its own bulk of water to slow the action. At full strength 1 to 10 minutes is needed, according to the amount of reduction wanted. After reduction, wash thoroughly and dry. The mixed solution keeps well in the dark, and may be used repeatedly.

Ammonium Persulphate.—The ammonium persulphate reducer particularly attacks the heavier deposits, and is in consequence very suitable for hard over-developed negatives, particularly of very contrasty subjects. A suitable formula is:—

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Ammonium persulphate .	175 gr.	(10 gm.)
Water to	10 oz.	(250 c.c.)
Sulphuric acid . . .	2 drops	(2 drops)

This solution must be made up as required. The negative, which must be free from hypo, is immersed in this, with continuous rocking, until either sufficient reduction is obtained or the solution becomes milky. In the latter case, transfer the negative to water, and prepare a further supply of reducer. When reduction has gone nearly, but not quite, far enough, the negative is transferred to a " stop bath " of 5 per cent. sodium sulphite, which immediately arrests the action.

The water used should be as pure as possible, for chlorides, even in minute amount, will entirely inhibit the reducing action. If the reducer refuses to work, addition of a drop or two of very dilute silver nitrate solution, which precipitates out the chlorides, will generally start the action.

Proportional Reducer.—As a corrective of simple over-development, this is a most satisfactory reducer. Make up :—

A.	Potassium permanganate .	2½ gr.	(0·25 gm.)
	Sulphuric acid, 10 per cent.	144 min.	(15 c.c.)
	Water to . . .	20 oz.	(1000 c.c.)
B.	Ammonium persulphate .	220 gr.	(25 gm.)
	Water to . . .	20 oz.	(1000 c.c.)

Both these solutions keep well. For use, take 1 part of A to 3 parts of B. When reduction has gone far enough, transfer to a 5 per cent. solution of potassium metabisulphite, which will both check the action and clear the stain. If ineffective in removing the stain, transfer to a second bath of metabisulphite.

Plain Permanganate.—This is also a very satisfactory reducer, and is easy to prepare. The stock solutions are:—

A.	Potass. permanganate .	26 gr.	(3 gm.)
	Water to . . .	20 oz.	(1000 c.c.)
B.	Sulphuric acid (conc.) .	50 min.	(6 c.c.)
	Water to . . .	20 oz.	(1000 c.c.)

The working solution is made by adding 1 part each of A and B to 10 parts of water. The stock solutions will keep for long periods, but a waxed cork should be used for A. After reduction, clear in a 5 per cent. solution of metabisulphite, and wash well.

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Reduction by Toning.—When a moderate amount of reduction, strictly proportional in character, is required, the image may be toned blue with an iron toner (see TONING). The negative looks denser to the eye, but gives much softer prints than before. If desired, the image can be restored to its original state by rinsing the toned negative in changes of dilute sodium carbonate solution till all blue colour is gone, and then redeveloping in any bromide paper developer.

Ferric Sulphate. This is a very convenient proportional reducer for amateur work, as it is inexpensive and keeps well. A suitable formula is :—

Ferric ammonium alum . . .	2 parts
Rain or distilled water . . .	100 parts
Sulphuric acid	½ part

When reduction has been carried far enough, immerse in very dilute (about 0·1 per cent.) sulphuric acid for a few minutes before washing. Tap water containing chlorides must not be used.

Iodine and Cyanide.—This reducer can be used for negatives, but is more generally recommended for bromide prints.

A.	Potassium iodide . .	1 oz.	(50 gm.)
	Water	5 oz.	(250 c.c.)
	Iodine	½ oz.	(25 gm.)
B.	Potassium cyanide . .	½ oz.	(25 gm.)
	Water	5 oz.	(250 c.c.)

For use take A 6 parts, B 1 part, water 100 parts. The B solution is exceedingly poisonous. (See POISONS.)

Reduction of Prints.—Over-dark bromide prints, including those that have been sulphide-toned by any process, may be reduced in :—

Common salt . . .	40 gr.	(2 gm.)
Potassium permanganate .	1 gr.	(0·05 gm.)
Sulphuric acid . . .	10 min.	(0·5 c.c.)
Water to	10 oz.	(250 c.c.)

The print should be hardened before treatment. If the action is too rapid, the reducer may be further diluted. When sufficient reduction has taken place, the print is transferred to an acid fixing bath for a minute or two, then washed and dried. Any remaining stain can be removed by treatment in a solution of potassium metabisulphite.

Farmer's reducer is also very valuable for prints, but should be used much more dilute, or with a lower proportion of

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ferricyanide, than for the reduction of negatives. One part of ferricyanide stock solution (above) to 100 parts of hypo solution should be tried first; if reduction is too slow, the amount of ferricyanide can be increased. Papers vary a good deal in their susceptibility to the action of this reducer. Staining, which occurs with some papers, can largely be prevented by adding about 1 per cent. of ammonia to the mixed reducer.

Local Reduction.—Any of the foregoing reducers can be applied to part of a negative or print with a camel's-hair brush or a wad of cotton-wool screwed up to a point. When locally reducing a print, the print should first be soaked in water and then blotted surface-dry. As soon as a little reduction takes place, the print is flooded with water and inspected; if necessary, the application can be repeated in the same manner.

Spirit Reducer for Prints.—The following spirit reducer can be applied locally to a dry print:—

A.	Iodine . . .	40 gr.	(2 gm.)
	Methyl alcohol . .	2 oz.	(50 c.c.)
B.	Thiocarbamide . .	80 gr.	(4 gm.)
	Water to . . .	2 oz.	(50 c.c.)

For use, mix equal parts of A and B, diluting with water if only slight reduction is required. Apply locally with a small brush and immediately swab with methyl alcohol in a tuft of cotton-wool. Blot off any excess of alcohol, and repeat until the desired reduction is obtained. Transfer direct to clean hypo, *without* a preliminary rinse, then wash as usual.

Lantern Slides can be reduced, locally or otherwise, by any of the methods given for negatives or prints.

See also BASKETT'S REDUCER.

Refill. 36 exposure length of 35-mm. film for pictures 24 × 36 mm., with ends ready trimmed for loading, in the dark-room, into a cassette. Usually packed, in black paper, in a small aluminium tube. Daylight-loading refills for reloadable cassettes are also offered by several makers.

Reflected Light is the light obtained from the surface of any body that is not itself a primary source of light energy. In portrait work, the term is applied to the light obtained by reflection from any mirror or white surface. It is extremely useful in portraiture for lighting up the shadowed side of a sitter's face; care should be taken, however, that too much reflected light is not used, or the result will be a hard and lifeless

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picture. Mirrors should rarely be used, and a rough, not too white surface is the best.

Reflection Density. Density (*q.v.*), measured by reflected light, as when finding the depth of tint produced by the photographic image on printing paper. If a piece of fogged film transmits one-tenth of the light falling on it, it has a density (or transmission density) of one ; similarly if a piece of fogged paper has so darkened that it reflects one-tenth of the light falling on it, it has a reflection-density of one.

Reflection in Lenses. Reflection of light from the surfaces of the component glasses of a lens leads to the diversion of an appreciable portion of the incident light from its intended path (see Loss of Light in Lenses). Some of this reflected light is sent back towards the object, and so does no harm, but some undergoes a second reflection and is diverted back to the sensitive surface. It may give rise either to faint but more or less well-defined images (see Flare and Lens) or alternatively may simply be spread more or less evenly over the image, degrading its contrast and producing a foggy negative.

The number of parasitic images that can be formed depends on the number of separate component-glasses (single or cemented) making up the lens, and rises very fast as the number of components increases. (Number of images $= 2n^2 - n$, where n = number of components.)

Separate Components .	1	2	3	4	5
Parasitic Images. .	1	6	15	28	45

Those of the parasitic images that are completely out of focus on the sensitive surface give rise to the general fog mentioned above.

The parasitic images considered here are those that arise from two successive reflections, and if the glass surfaces concerned are not bloomed the reflection at each will contain about $6\frac{1}{2}$ per cent. of the total incident light at that surface, so that after a double reflection the parasitic image will be approximately one two-hundredth as bright as the legitimate image. If a bright object in the subject is two hundred times brighter than a deep shadow, and if the parasitic image of that bright object coincides with the normal image of the shadow, then that image will show up clearly as an area of double brightness. Ranges of subject-brightness far higher

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than 200 to one are found in night subjects that include street lamps or other light-sources, so that parasitic images of them (if they are approximately in focus on the film) must be expected.

If the lens is coated on all surfaces the intensity of reflections can be reduced to less than 1 per cent. of the brightness of the incident light, bringing the quantity of light in a parasitic image down to less than one ten-thousandth of that in the primary direct image, which is about one-fiftieth of that with an uncoated lens. The improvement given by coating the surfaces is so great as hardly to need stressing; parasitic images are so weakened that they cease to be noticeable save in exceptionally difficult circumstances, and the reduction to one-fiftieth of the stray light distributed, as slight fog, over the negative as a whole makes a most valuable contribution towards cleaner negatives with better shadow gradation. Naturally the improvement is most marked in subjects of high contrast.

Figures for the loss of contrast and general degradation of the image caused by reflected light cannot be given in general form; they depend on the nature of the subject, the design of the individual lens used, and on the presence or absence of an efficient lens-hood. Some experiments with uncoated lenses have shown that the amount of light illegitimately finding its way into the shadow-portions of the image was sufficient to reduce the contrast of an outdoor portrait, taken on a sunny day with white clouds, to the following percentages of the contrast of the actual subject:

	No Hood.	With Hood (%).
f/3·5 lens at *f*/3·5 . . .	60	89
f/3·5 lens at *f*/6·3 . . .	72	94
f/2 lens at *f*/2 . . .	37	63
f/2 lens at *f*/6·3 . . .	52	84

In an interior subject, an *f*/2 lens at *f*/2, without hood, gave 28 per cent. of subject-contrast when the subject was seen against a white background, but 90 per cent. when the background was black.

In addition to stressing the superiority of the simpler lens the need for a hood to cut out light which, though outside the field of view of the picture, nevertheless adds to the amount of reflected light within the camera, is made very evident indeed. (See LENS-HOOD.)

Reflector. See PORTRAITURE, also ARTIFICIAL LIGHT.

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Reflex Attachment. See REFLEX HOUSING.

Reflex Camera. Camera in which the image is reflected, by means of a mirror, to a horizontal focusing screen at the top of the camera. (See CAMERA and MINIATURE CAMERAS.)

Reflex Copying. A direct copying process for line work. A sheet of sensitive development paper is laid face downwards on a print—as an engraving in a book—pressed into contact, and the back of the paper is exposed to light, when, if the exposure was correct, a developable image is obtained. The process is sometimes called *Playertype*, after J. H. Player, who was chiefly responsible for bringing it into prominence. The details of working are as follows: A drawing-board is laid on the table. On this a sheet or two of stout blotting-paper. Next comes the drawing to be copied, face upwards. On this is laid a sheet of ultra-contrasty bromide paper, coated side downwards, so that the sensitive side of the bromide paper is in contact with the surface of the drawing. Over the back of the bromide paper is laid a sheet of green or yellow glass, and over this a sheet of thick plate glass. The exposure is then made by illuminating the back of the paper, through the glass, for a suitable time. All parts of the emulsion are exposed, and so to some extent fogged, but where the sensitive surface is in contact with a black line on the original being copied, less light is reflected back than from the white paper. It is on this difference in reflecting power that the formation of the image depends. By using a contrasty paper, a highly restrained developer tending also to contrast, and adjusting the exposure accurately, very satisfactory copies can be made. Special papers for reflex copying are marketed by several manufacturers, whose instructions as to exposure and development should be closely followed.

Reflex Housing. Accessory, consisting of a box containing a mirror at 45° to the vertical that deflects light to a focusing screen at the top of the box. The housing is placed between the lens and the body of a non-reflex camera, and means are usually available to synchronize the raising of the mirror (to permit light to pass to the film and to cover the focusing screen) with the releasing of the shutter. This attachment permits a non-reflex camera to be used as a reflex for special purposes—*e.g.*, extreme close-up work, or when using a long-focus lens. Such attachments are suitable only for cameras having a focal-plane shutter.

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Refraction of Light. When a ray of light passes obliquely from one transparent medium to another it suffers refraction, or is bent out of its course, as it passes the surface separating the two media. Refraction takes place according to well-known laws. The first of these is that the incident, the normal, and the refracted rays are in the same plane, and the second that the sine of the angle formed by the incident ray with the normal bears a constant ratio to the sine of the angle formed by the refracted ray with the normal. This ratio is the refractive index of the substance. It is different in value for light of different wavelengths, being greatest for violet and least for red. This fact is taken into consideration in the achromatising of lenses. (For further information on reflection and refraction the reader is referred to any elementary work such as *Light for Students*, by Edwin Edser (Macmillan) or *Optics*, by W. H. A. Fincham (Hatton Press).) (See also LIGHT.)

Regression of Inertia. Increase in H & D speed of an emulsion with prolonged development. This effect is due to the presence of soluble bromide in either the developer or the emulsion. (See SENSITOMETRY.)

Regression of Latent Image. Fading of the latent image in the undeveloped film after exposure. With the great majority of monochrome films the effect is too small to be of practical importance, but with some of the ultra-fast films a negative that would have been correctly exposed if developed within a day or two of exposure may prove so underexposed as to be useless if development is postponed for a month or two. Regression is most dangerous in reversal colour films; if, as is probable, it does not take place to the same extent in all three emulsion layers, the colour-balance will be upset. This supplies the main reason for the advice commonly given to process such films within a month, at most, of making the first exposure.

Rehalogenising. The re-conversion of the silver image in a finished print or negative into silver chloride, bromide, or iodide.

Any of the bleachers given under *Sulphide Toning* (see TONING) will perform this conversion. If a bichromate bleacher is used (see *Chromium Intensifier*, under INTENSIFICATION) the image will develop up darker than before if exposed to light and developed. (See also REDEVELOPMENT and HARMONISING HARSH NEGATIVES.)

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Relative Aperture. F-number. See DIAPHRAGM.

Release, Shutter. See SHUTTER RELEASES.

Relief, Photographs in. See BAS-RELIEFS.

Repeating Back. Fitting for back of camera allowing several photographs to be taken on one plate. It usually consists of a specially-made dark-slide that registers in several successive positions with the picture-opening in the back of the camera.

Replenisher. Solution to be added to a developer or other solution to regenerate it after use. See DEVELOPMENT.

Residues. Of the silver compounds initially present in film or printing paper, part only is used to form the image; most of the remainder, which is normally considerably more than half, is eventually to be found in the fixing bath. It is not worth while for the amateur to attempt to recover this silver, as the quantity involved is too small, but for the professional doing a good deal of work, or a busy D. & P. organization, silver recovery can make a useful saving in overall expenses. Very roughly, the value of silver recovered is about twenty shillings for every hundred pounds worth of sensitive material processed.

The methods available for separating out the dissolved silver fall into two broad classes, chemical and electrolytic, the latter methods having the advantage that the hypo is to a considerable extent regenerated during the process, so that with the occasional addition of fresh hypo a batch of fixer can be kept in use for a considerable time. The saving in chemicals may easily be worth more than the silver recovered.

One of the oldest chemical methods involves the addition of caustic soda and sodium or potassium sulphide; this precipitates the silver in the form of a sludge of silver sulphide which can be separated out and sent to the refiners. This process must not be carried out where the smell of hydrogen sulphide can reach sensitive materials, or they will be fogged, and the hypo cannot be re-used.

Alternatively the hypo may be acidified with acetic acid, and then treated with metallic zinc or iron filings, which precipitate the silver as a sludge of impure metal. Again the hypo cannot be re-used, but if the silver is precipitated

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by sodium hydrosulphite the remaining clear liquid can be brought up to strength by the addition of some hypo, together with acidifier and hardener, and taken back into service for the further fixing of negatives. It should not be used for prints.

Electrolytic methods can be applied while the hypo is actually in use, so that the extraction of silver, with accompanying regeneration of the hypo, can become a continuous process. For the large-scale user electrolysis can be carried out with current drawn from the mains, which involves the setting up of a certain amount of electrical equipment. For work on a smaller scale, the necessary current can be generated by the very simple means of immersing in the fixer two plates of dissimilar metals which, with the dissolved chemicals, form a primary cell. In either case, the silver plates out, as metal, on one of the electrodes.

Fuller details of all these processes, together with some necessary addresses, will be found in the Kodak Data Sheet No. P.R.9, from which the above abbreviated descriptions are derived.

Resolving Power. Expression of the fineness of detail that can be recorded by a lens or emulsion. The subject considered consists of parallel black lines separated by white spaces of width equal to the thickness of the lines. A lens (or emulsion) is said to have a resolving power of 40 lines per millimetre if the smallest image it will form (or record) without the lines becoming indistinguishable from one another by blurring is on the scale thus indicated. In practice, the resolving power of either lens or emulsion depends on the blackness of the lines and the whiteness of the spaces; in addition, that of the emulsion depends also on exposure and development. Figures quoted normally refer to the blackest lines, and the whitest spaces, conveniently obtainable on a paper surface, and with exposure and development adjusted to produce the highest resolution that the emulsion will give.

Restoring Faded Photographs. See FADED PRINTS.

Restoring Old Bromide Paper. See BROMIDE PAPER.

Restrainer. See DEVELOPMENT. In spite of the advantages of the more recent organic restrainers ("antifoggants"; "developer improvers") such as benzotriazole, a bromide, normally in the form of potassium bromide, remains in widespread use as a restrainer. The main purpose of the addition

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is to check fog due to causes other than the access of light to the emulsion being developed; in doing so a bromide tends also to prevent the development of faint shadow detail, and so in effect slows the film. The main advantage of the organic restrainers is that they act more selectively against fog than does bromide; if added in quantities carefully worked out for the emulsion and developer in use, they can often check chemical fog without affecting shadow detail. Organic restrainers are perhaps more widely used in printing than in negative making; besides restraining fog (they are invaluable with stale and "mealy" papers) they provide a most useful control over image-colour and add considerably to the latitude in exposing and developing times.

Nevertheless with reasonably fresh printing papers, and negative material not of the highest speed, bromide remains an entirely satisfactory restrainer. It is generally added in large quantities to developers for line copying and other purposes where it is necessary to develop to high contrast and yet keep the negative completely clear of fog. In such applications some loss of speed does not matter.

Reticulation. The breaking up of gelatine on a photographic film or plate in such a way as to give rise to a network of fine lines. Reticulation may occur simply as a result of processing at too high a temperature, so that the gelatine becomes unduly soft. Usually, however, reticulation is the result of sudden contraction or expansion of the gelatine as a consequence of a sharp change in temperature while the gelatine is swollen with water.

Reticulation of the gelatine bearing the image cannot be cured or concealed, for the image itself is broken up. But reticulation of the gelatine backing of roll film, which is more often met, can be concealed by printing or enlarging with a very diffused light, or by treating the damaged surface with a varnish having the same index of refraction as gelatine. Adding an extra gelatine coating is perhaps the most perfect cure of all.

Retouching. The process of improving a negative or print by handwork. The term is most generally applied to the improvement of portrait negatives by knife and pencil, the former removing excessive deposit by scraping, the latter adding density in the shadows where required. Retouching is generally directed to smoothing out wrinkles, freckles, and

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other such defects in the sitter, and to removing or lightening over-dark shadows caused by unsuitable lighting.

The first qualification for a retoucher for portraits is a sound, if general, knowledge of the anatomy of face and hands; this may come by deliberate study, or by experience and observation. Considerable artistic skill is also needed.

As it is necessary to be able to see through the negative when working upon it, a retouching desk (*q.v.*) is required. The amateur retoucher will do well to avoid the use of the knife, as considerable skill is needed in its use, and mistakes cannot be rectified. Pencil work is another matter; being applied not to the actual surface of the negative, but to a film of retouching medium that can be cleaned off if desired, any unsuccessful work can readily be removed.

Retouching medium may be bought ready prepared, or the following may be made up:—

Sandarac	12 gr. (1·35 gm.)
Shellac	72 gr. (8·2 gm.)
Mastic	72 gr. (8·2 gm.)
Ether	3 oz. (150 c.c.)
When dissolved add Benzene .	½ oz. (25 c.c.)

The medium is applied with the finger-tip, or a scrap of cotton-wool; just a smear is all that is needed.

For a thin negative a hard pencil (3H or 4H) is best, but for a denser negative a softer pencil will be needed or it will not be

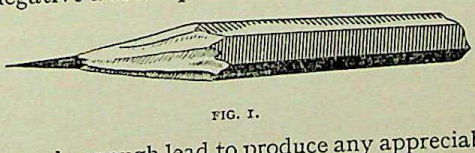

FIG. 1.

possible to apply enough lead to produce any appreciable effect. The point should be long and extremely sharp, and a piece of fine emery paper should be kept at hand for resharpening. Fig. 1 gives an idea of the type of point required.

To fill in a wrinkle in a portrait, go over it with a series of dots or other fine strokes until it is sufficiently darkened. A print should be made every now and then to see the effect of the work done. If unsatisfactory, the medium, and with it the pencil work, can be removed by rubbing over with a rag moistened with turpentine. If more work is required than the medium will take, varnish it over, and when dry apply more medium and continue the work.

The top sketches of Fig. 2 show the various methods of

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applying the retouching pencil in order to obtain a tone that is both even and a good match to the surrounding tone. It is immaterial which style is adopted so long as it is applied *regularly* throughout the entire patch.

The lower sketches show how to fill a blank tone. The point to remember is that a better chance of making a successful join all round the edges is obtained by leaving a narrow margin

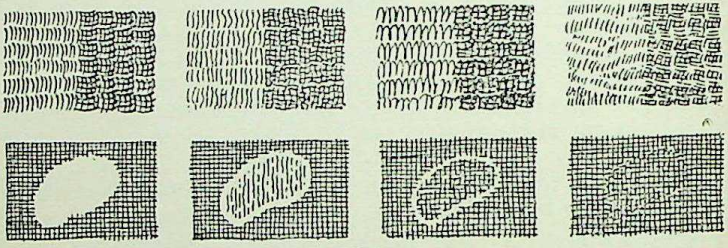

FIG. 2.

all round at the outset. Do not attempt to match the surrounding tone *immediately*, as it is much better to apply one light tone first, adopting any of the styles shewn, and then to apply a second over-laying tone, and so on until the two tones are finally matched. The last stage is to fill up the blank margin to " wed " the two tones. In this way it is easier to judge the matching of the two densities, and it also eliminates the tendency to begin with a heavy stroke in attempting to begin at the edge, which leads to an unnecessarily heavy " join."

It sometimes happens that a negative has thin shadows—though full of detail—and hard lights, the shadows being too black by the time the lights are printed up. Rub some crimson lake on the palette, getting it pretty thick. Put the negative on the desk, *glass side towards one.* Moisten the tip of the finger with the lips and rub on to the colour, and dab on to the shadows to be held back ; repeat until the whole is evenly coloured. Small spaces to be coloured, such as hands in shadow, shadows under brows, etc., treat in the same way.

For lightening large or small areas, neo-coccin solution may be applied to the film side with a brush. Two solutions, one more dilute than the other, may be used. For the weaker solution, dilute a stock solution of the dye until a touch on the clear rebate of the negative produces a just-visible tint. The other solution may be about five times as strong. The gelatine takes up the dye-solution, allowing several faint washes to be superposed before the negative has to be placed on one side to dry.

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If an attempt is made to put on all the colour needed in one application, the edges of the coloured area are likely to be very visible. A check of the effect can be made at any time by printing ; it is difficult to gauge visually at first. Neo-coccin can be washed out quite readily if the work is not successful.

To diminish the density of small areas Baskett's reducer (*q.v.*) may be used, applying it with a small skin stump. Abrasive pencils for the same purpose can be made by melting as much fine pumice as possible into hard paraffin wax, and casting the mixture in moulds made by rolling paper round a pencil. The resulting cylinder can be pointed as desired, and after being rubbed down the negative can be freed from greasiness with a light petroleum spirit (ligroin or " benzine ").

To retouch for broad effects an excellent plan is to cover the back of the glass with collodion slightly tinted with a colouring material. When dry the film is scraped away where not wanted ; that is to say, where one wishes the negative to print with full vigour. A layer of matt varnish slightly tinted may now be applied, and a second scraping away to suit the subject can be performed. Shading with blacklead powder applied with a stump, and partial masking with fine tissue paper, may come in at this stage, while the paper may form a fresh basis upon which blacklead work may be done.

In the case of all considerable operations at the back of the negative, trial prints should frequently be made. (For retouching prints, see AIR BRUSH, COLOURING PHOTOGRAPHS, SPOTTING PRINTS, and ENLARGING ; see also BROMIDE PAPER.)

Retouching Desk. Support on which a negative may be placed for retouching or similar treatment, for which purpose it is essential to arrange that it should be viewed by transmitted light. A simple type of retouching desk may consist of a sloping piece of wood in which a rectangular hole is cut. Into this hole fit carriers for different sizes of negative. A mirror or white card is arranged horizontally below the opening to reflect light enough to enable the negative to be seen in comfort, and it is usual to provide an opaque screen round the top of the desk to prevent dazzle from the source of light, which is normally in front of the operator. More elaborate devices, in which the negative is placed on an opal plate electrically illuminated from below, are preferable where large amounts of work have to be done.

Reversal. The production of a negative in cases where a positive is more usual, or of a positive where a negative would

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normally be obtained. Reversal may be deliberate or accidental. One cause of accidental reversal is extreme over-exposure, as for example, when a brilliant lamp is included in a night scene, or the sun in a daylight exposure.

Accidental reversal quite frequently occurs when a partially developed negative is inspected by unsafe light. The negative image already developed up is printed by this light upon the underlying unexposed emulsion; on proceeding with development, this develops to give a positive. If this is stronger than the original negative, the latter is overwhelmed, and the result is a rather foggy positive.

Intentional reversal is used in making substandard ciné-films and in colour photography. Here a negative image is developed up as usual, but instead of fixing out the unused silver salts in thiosulphate (hypo), the negative image is dissolved away in acidified permanganate or bichromate. The unused silver salts are then either exposed to light and developed up, or are blackened by the application of a solution of sodium hyposulphite or hydrosulphite ($Na_2S_2O_4$—*not* common " hypo "). As the amount of unused silver salt is greatest where the original negative was least dense, this process produces a positive on material exposed in the camera. This method of working is readily applicable to the extra thin and completely even emulsions specially prepared for reversal working, but the more thickly coated emulsions made for negative work tend to give dense and foggy positives. This is avoided by incorporating a solvent of silver bromide, usually potassium or ammonium thiocyanate, in the first, and sometimes also in the second, developer. Details have to be worked out for the individual emulsion, but manufacturers, notably Ilford Ltd., will usually supply full instructions for the reversal processing of their own films.

Reversal processing of normal negative material finds special application in the preparation of 35-mm. filmstrips (*q.v.*) by photographing a matched set of bromide prints.

In the reversal tripack colour processes the same basic principle is used, but the second development is done in a colour-forming developer to give the three dye images as well as the positive silver images. The silver images are then bleached and fixed away, leaving only the dyes. In theory, at least, the negative silver images need not be removed before the second development (see COLOUR PHOTOGRAPHY).

It is not practicable to process bromide paper by reversal,

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as the unevennesses of the paper base inevitably reproduce themselves in the final positive image.

Reversed Negative. A negative in which the subject is laterally inverted, like a reflection in a mirror. Reversed negatives are required for certain photo-mechanical processes. They are generally made by placing a mirror or a reversing prism (see PRISM, REVERSING) over the lens at an angle of 45° to the axis of the latter. The camera is then pointed at right-angles to the object, which is photographed by reflection. Provided that the back of the plate is clean, and that in focusing due allowance is made for the thickness of the glass, a reversed negative can be made by photographing with the glass side of the plate facing the lens.

Reversing Back. Detachable square frame fitting on the back of a camera-body of square section. The dark-slide is carried in this frame, which can be detached, turned through 90 degrees, and then replaced to bring the plate or film from the horizontal to the upright position or vice versa. Compare REVOLVING BACK.

Revolving Back. A form of reversing back (*q.v.*) mounted on a turn-table so that the dark-slide can be revolved from one position to the other without removing it from the camera, and therefore without having to cover the plate by closing the dark-slide.

Rigid Mount. Alternative term for IRIS MOUNT (*q.v.*).

Rinsing after Development. For prints, an acid rinse consisting of 2½ per cent. acetic acid or of 2½ per cent. metabisulphite may be used, but for films a chrome alum hardening rinse (see HARDENING STOP BATH) is preferable.

Rising Front. A camera is said to have a rising front when the panel carrying the lens can be moved up so as to bring its axis above the centre of the plate. If movement in the opposite direction is also provided, the camera is said to have a " rising and falling front." The rising front is chiefly required in architectural work or street scenes where the tops of buildings are required in the picture. If they are included by tipping the camera, vertical lines will converge, giving the buildings the appearance of falling over backwards. This does not occur if the plane of the film is kept vertical and the tops of buildings are included by raising the lens, though

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marginal distortion is considerably increased whenever the rising front is used. (See DISTORTION.)

Where an extensive rising movement is fitted, it may happen that the bottom of the focusing screen (top of subject) is not properly illuminated; for such cases a swing front is often provided to allow the axis of the lens to be tilted back to the centre of the film. As the axis is then no longer perpendicular to the sensitive surface, extensive stopping down is required to provide adequate sharpness. It should be noted that the combined use of rising and swing fronts is exactly equivalent to tilting the camera and using a swing back to bring the sensitive surface vertical again. (See ARCHITECTURAL PHOTOGRAPHY; also SWING BACK.)

Rochelle Salt. Sodium potassium tartrate $NaKC_4H_4O_6 4H_2O$. M.W. = 282. Colourless clear efflorescent crystals, very soluble in water. Used in the preparation of gelatino-chloride printing-out papers, and as developing agent in the kallitype process.

Rodinal. Concentrated one-solution developer made by Agfa in Germany. The method of preparation is as follows: Work 34 gm. of paraminophenol into a cream with 340 c.c. of water. Add 558 gm. of a 30 per cent. solution of potassium sulphite at 55° C., followed by 50 gm. of a 34 per cent. solution of potassium hydroxide, then 5·52 gm. of potassium bromide dissolved in a little water, and finally 42 mgm. of anthroquinone-2, 3-triazole-sodium sulphonate. (The last is an anti-foggant.) Then filter and allow to stand 14 days.

Equivalent concentrated developers, also based on paraminophenol, are offered by several British makers, and a simpler formula for a similar preparation will be found under *Paraminophenol* in the article on DEVELOPMENT.

Roller-Blind Shutter. See SHUTTER.

Roll Film Adapter. Alternative, and now perhaps more usual, term for roll holder (*q.v.*).

Roll Films. See FILMS.

Roll Holder. A piece of apparatus for using roll-film in a camera designed and built for plates. It is applied to the back of a camera in the same manner as a dark slide or plate-holder, and a section of the film is wound up after each exposure as with an ordinary roll-film camera. (See FILMS.)

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Roof Prism. See PENTAPRISM.

Royal Photographic Society. Founded in 1853, it is the world's senior photographic society, with headquarters in London. It has a full programme of lectures and exhibitions mainly for the amateur photographer, but in addition has several " Groups," which are subdivisions within the Society, to cater for more specialized interests, in some cases of professional type. The Scientific and Technical Group has organized conferences which attract leading scientists from many distant countries, and the Medical Photography and Photojournalism Groups do comparable work in their own fields. Membership is about 7000, and the Associateship (A.R.P.S.) and Fellowship (F.R.P.S.) are real distinctions respected throughout the photographic world. Publications: the *Photographic Journal*, the *Journal of Photographic Science*, and *Photographic Abstracts*, the last being sponsored by the S. & T. Group.

Rubber Mountants. See MOUNTANT.

Ruby Light. See DARK-ROOM, also SAFELIGHT.

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Sabattier Effect. The partial or complete reversal of an image by exposing the partly developed material (film or paper) briefly to light and then continuing development. (See REVERSAL.) This procedure, usually only taken as far as partial reversal, has frequently been used as a pictorial device. The effects, however, are very difficult to predict, as the original exposure, the extent to which development is carried before exposure to light, the length of that exposure, and the degree of subsequent development all play a part in determining the final result.

Safe Edge. See CARBON PROCESS.

Safelight. Coloured screen or glass for the dark-room lamp, but the term is often also applied to the lamp as a whole. A safelight screen has to be chosen for the material to be used. For fast orthochromatic and non-colour-sensitive films a deep red colour is generally used, but for bromide or chlorobromide paper a yellow or orange-yellow safelight is much to be preferred. For panchromatic films a deep green offers the greatest safety for its visual effect, but so little light is permissible that the amateur generally prefers complete darkness.

Safelight screens are made by coating glass with a solution of gelatine coloured by a suitable dye. A complete series of screens, each precisely calculated to give the best possible compromise between safety and brilliance of illumination when working with the particular sensitive material for which it is designed, is offered by several makers.

Safelight, to Test. The suitability of a safelight screen for the material to be used, and the power of the light-source that can safely be placed behind it, can readily be tested by experiment. This is done by exposing to the light of the lamp

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a sample of the sensitive material to be used, giving different parts of the sample different exposures, test-strip fashion. On development, the time during which exposure to the lamp is safe, at the distance at which the test was made, can be seen by observing the longest exposure that does not produce fog.

Note that too safe a light is to be avoided ; a bright light which will fog the material unless it is protected as much as possible during handling is infinitely preferable to a very dim light to which the material may be freely exposed, but which leaves the darkroom in such obscurity that work is perpetually hampered by lack of light. (See also DARK-ROOM.)

Safety Film. Film coated on a non-inflammable base.

Salt. In general, the class of substances formed by the combination of an acid with a base. If, for example, iron rust (iron oxide, a base) is dissolved in sulphuric acid, the acidity of the latter is largely neutralized and the salt iron sulphate is formed. When dissolved in water, salts are partially broken up (hydrolysed) into acid and base, both being present together in the solution. If base and acid are both strong, or both weak, the solution is approximately neutral, but if one is strong and one weak, the solution will be correspondingly acid or alkaline. A salt such as potassium carbonate or sodium phosphate (strong base, weak acid) can thus serve as an alkali in developers.

" Salt," as distinct from " a salt," normally means sodium chloride (NaCl), the substance found in a " salt-cellar " on every table. To avoid confusion, sodium chloride is often referred to as " common salt."

Salted Papers. See PLAIN (SALTED) PAPERS.

Saturated Solution. A solution which will take up no more of the dissolved substance. (See SOLUTIONS AND SOLUBILITY.)

Scales. See SOLUTIONS, MAKING UP.

Scattered Light. See REFLECTION IN LENSES, COATED LENSES. Also IRRADIATION.

Scheiner. See *Emulsion Speed*, under SENSITOMETRY.

Schlippe's Salt. See SODIUM THIOANTIMONIATE ; also TONING.

Scratch-Proof. A film is said to be scratch-proof when its surface has been hardened as a safeguard against mechanical damage by abrasion or otherwise. Ordinary hardening

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agents (formalin, or an alum) may be used, though the effect of an alum is not so much to harden the gelatine as to render it insoluble, even in hot water. Formalin gives a harder surface, but a mixture containing tannic acid is even more effective. The following bath hae been recommended (*British Journal of Photography*, 87, 65, 1940) as giving a particularly hard and scratch-proof surface.

Tannic acid	1 part
Hot water	36 parts

When cool add

Formalin	4 parts

For use 1 part of the above is added to 15 parts of water, and the film is immersed in this for five minutes towards the end of the usual period of washing. Washing is then completed as usual and the film is dried. Grease, due to finger-marks or other causes, must be most scrupulously avoided, and it is advisable not to touch the surface of the film with the fingers until it is very thoroughly dried. (See also HARDENING FIXER, HARDENING STOP-BATH, and FORMALIN.)

Screen, Lantern. See PROJECTOR.

Screen Plates. See COLOUR PHOTOGRAPHY.

Screen, Ruled. See PHOTO-MECHANICAL PRINTING PROCESSES.

Sculpture, Photographic. See BAS-RELIEFS, PHOTOGRAPHIC.

Sease. Dr. Sease, an American investigator, has published fine-grain development formulæ employing paraphenylene diamine and glycin. These developers are usually known as "Sease I," "Sease III," etc. (See FINE-GRAIN DEVELOPMENT.)

See-Saw Development. A method of developing a length of film by drawing it to and fro through the developer instead of immersing it bodily. See FILMS.

Selenium. Se =79. Non-metallic element closely related to sulphur. Normally obtained in the form of a black powder. Specific gravity 4·8, melting-point 219° C., boiling point 690° C. Insoluble in water, but dissolves slowly in solutions of sulphides or sulphites to form seleno-sulphide and selenosulphate respectively. These solutions are used for toning (*q.v.*)

Self-Toning Paper. A variety of printing-out paper, for contact prints by daylight, in which the necessary chemicals for toning were incorporated in the paper itself, which therefore

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only required fixing. It was made both with gelatine and collodion base. (See GELATINO-CHLORIDE PAPER and COLLODIO-CHLORIDE PRINTING-OUT PAPER.) Though once very popular, it is now obsolete.

Sensitometry. The science of sensitometry is primarily concerned with studying the effect upon the sensitive material of the two factors exposure and development. The results obtained from a quantitative examination of plates and films from this point of view lead on to methods of expressing emulsion speed, contrast, and rate of development, and as these are the fundamental facts that every photographer needs to know about his sensitive material, every amateur should learn to appreciate at least the elementary principles upon which sensitometry rests.

Photography was developed empirically rather than scientifically, so that for many years photographers really knew very little about the material they were using. The first scientific work in sensitometry was done in 1890 and following years by Hurter and Driffield, whose initials are known to all older camera-users through the "H. & D." system of plate-speed determination they originated.

Exposure.

In sensitometric work the term "exposure" means "total light action" rather than "exposure time." Two sections of a plate are said to have received the same exposure even if one had 1 sec. exposure to a 10 candlepower light, and the other had 10 secs. exposure to a light of 1 candlepower. Subject to certain minor limitations (see RECIPROCITY LAW), exposure may thus be defined as the product obtained by multiplying the intensity of illumination at the surface of the plate by the time during which the plate is exposed to this illumination.

If a plate is exposed to a constant light in a series of steps, giving exposures of 1, 2, 3, 4, 5, etc., seconds, it is found on development that the apparent difference in blackness between successive steps becomes less and less towards the end that was given the longer exposures. Each successive increase in exposure of 1 sec. therefore produces less effect than the last.

That this should be found seems reasonable enough if the attention is fixed on the ratio of successive exposures instead of upon their difference. The 2 sec. strip has had double the exposure of that given 1 sec., but the strip receiving an exposure of 21 secs. has only had 5 per cent. more than the

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preceding strip to which 20 secs. were given. It is actually found by experiment that if in exposing a plate in steps each step is given double the exposure of the last, then the difference in blackness between successive strips appears about the same throughout.

In expressing graphically the measurements made in connection with sensitometry it is therefore the rule to use a scale so chosen that exposure-steps resulting in equal percentage increases in exposure are the same length at all parts of the scale. This condition is fulfilled by a logarithmic scale, which has the property that successive equal steps along it correspond to equal proportional increases in exposure. A " doubling-up " series of exposures such as 1, 2, 4, 8, 16, 32, etc., seconds. would be marked on a logarithmic scale by a succession of equal steps.

On a graph giving the results of sensitometric measurements it is usual to mark a 1-sec. exposure as 0, a 10-sec. exposure as 1, a 100-sec. exposure as 2, and so on, in which case the figures 0, 1, 2, etc., being the logarithms of the actual exposures, are evenly spaced along the scale. By adopting this method of marking exposures the need for specially-ruled paper is avoided, and ordinary squared paper can be used.

Density.

In considering the light-stopping power of successively more opaque strips on the developed test-plate much the same result is found, and the difference between two steps, one of which passes half as much light as its neighbour, appears about the same to the eye no matter whether the strips are light or dark. If one passes 1/10th of the light and the other 1/20th, their difference in blackness seems the same as that of a pair passing respectively 1/100th and 1/200th of the light falling on them. This, indeed, is inevitable, for by illuminating the latter pair with a light ten times as strong as that illuminating the former pair, the amount of light actually reaching the eye would be precisely the same in the two cases. These results, again, are best expressed by a logarithmic scale.

The term *density*, though very loosely used in ordinary work, is carefully and accurately defined for the purposes of sensitometry. The density of a deposit is formally defined as the logarithm of the reciprocal of the fraction of the incident light that it transmits. Clear glass has a density of 0, a deposit passing 1/10th of the light has density 1, a deposit passing 1/100th of the light falling on it has a density 2, and

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so on, each successive decrease of the transmitted light to 1/10th of its previous value increasing the figure for the density by one.

A Sensitometric Test.

With the terms that we shall use now carefully defined, let us follow the making of a simple sensitometric test. To a light of known intensity at a fixed distance, a plate is exposed, without the interposition of any lens or camera, in a series of steps, the times of exposure forming a " doubling-up " series or bearing some other convenient logarithmic relationship to one another. The plate is next cut into strips in such a way that each strip contains exposures covering the whole range (see Fig. 1).

These strips are then immersed together in a developer of known composition held at a known temperature, and are withdrawn for fixation at different stages of development—to take concrete figures, one may be withdrawn after 4 minutes, the next after 5, the next after 7½, and the last left in till 10 minutes have expired since development began.

After washing and drying in the usual way the density of the deposit on each step of each of the four strips is measured. This can be done in several ways, but in all cases the method used amounts to putting a source of illumination behind the plate and comparing the amount of light passed through it with the amount of light received in an uninterrupted beam from the same source. (See DENSITOMETER.)

The Characteristic Curve.

The figures so obtained are most easily grasped if they are exhibited in the form of a curve on squared paper, which presents the experimental results in the clearest possible way.

A set of curves, corresponding to the measurements made on the test plate of Fig. 1, is shown in Fig. 2, to which reference will again be made in connection with the relationship between contrast and development time.

One of these curves, enlarged for greater legibility and idealized to make discussion of it simpler, is shown in the full-page diagram Fig. 3. From this a great number of important deductions may be made.

For the smallest exposures (log E less than about 0·7) a constant density of about 0·1 is given, and does not decrease with decreasing exposures. If the support (glass or celluloid)

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is colourless, this density, since it appears even on unexposed emulsion, represents a trace of fog. It is usually called the "fog-level."

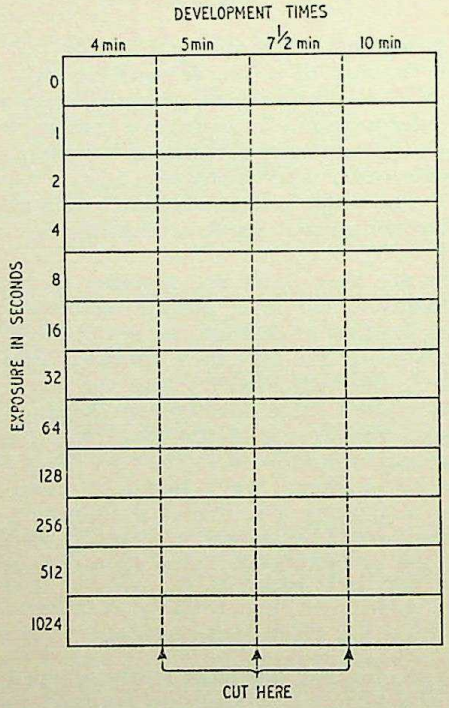

FIG 1. Showing the making of a sensometric test.

Up to about log E = 0·8, exposure does not produce any further developable deposit, but from this point on, each increase in exposure results in an increase in density. At first successive equal increases in log E produce larger and larger increases in density, as is shown by the steady steepening of the curve, but after reaching an exposure for which log E = 2, the curve becomes a straight line.

This straightness is maintained over a wide range of exposures (up to log E = 4·75). The fact that the curve is straight

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means that in any part of this range a doubling of the exposure (increase of 0·3 in log E) results in the same increase in density, which is the condition that has to be fulfilled if the densities in the negative are to be a true transcription of the brightnesses of the subject photographed. This range is therefore marked in Fig. 3 as " Region of Correct Exposure."

For much higher values of log E (above 4·75) this proportionality fails, as is shown by the departure of the curve from straight-line form. The lack of straightness betokens

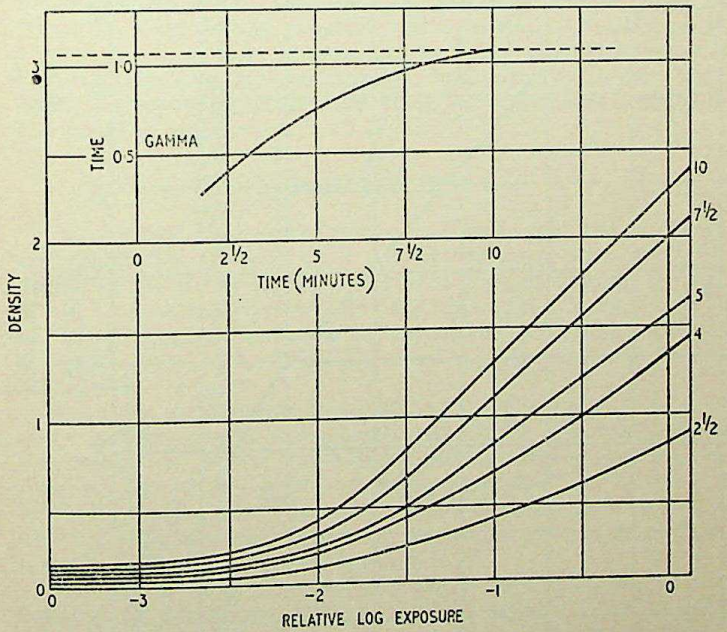

FIG. 2. Characteristic curves for five different development times. Inset-curve showing relation of gamma to time of development.

incorrect tone rendering, and as this incorrectness arises when exposure is too prolonged, this part of the curve is marked " Region of Over-Exposure."

The foot of the curve, which is also not straight, is marked " Region of Under-Exposure." That only untrue representation can be given by exposures in this latter region is shown by the fact that two exposures of 10 and 20 sec. show

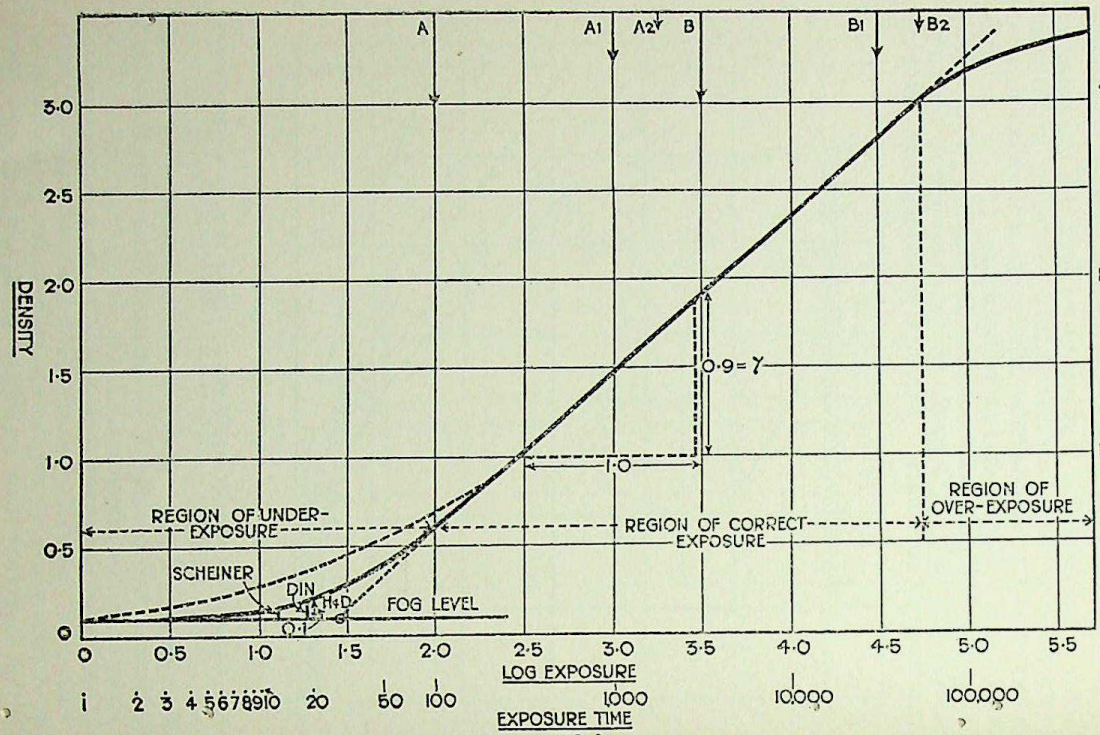

FIG. 3.

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densities of 0·14 and 0·21, with a difference of only 0·07, while exposures of 50 and 100 sec. show densities of 0·42 and 0·59, a difference of 0·17. Although in both cases one exposure is double the other, the smaller density difference is barely large enough to be perceptible while the other is very distinct indeed.

A negative whose tones included this part of the curve would evidently show more contrast in the half-tones than in the shadows, and more contrast in the high lights than in the half-tones. Any practical photographer will recognise this as a description of an under-exposed negative, but it must be borne in mind that in practice part of the toe of the curve is always used, partly because some tonal distortion in the extreme shadows is unnoticeable, and partly because such distortion is, to an extent, corrected by the characteristics of the printing paper used.

Contrast and Gamma.

Comparison of a negative such as this with the curve of Fig. 3, makes it clear that the low-contrast shadow detail corresponds to the nearly horizontal foot of the curve, and the increasing contrast towards the high lights corresponds to the steepening of the curve as the region of correct exposure is approached. The steepness or slope of the curve is thus a measure of contrast.

Since the contrast of a negative depends on the time of development, it is to be expected that if four separate parts of the test-plate of Fig. 1 are developed, as was suggested, for different times, the curves resulting from the four strips will have different slopes. Reference to the set of curves in Fig. 2 will show that the increase in slope as the development time is extended is very evident indeed.

The steepness of the curve is taken as a measure of the contrast to which the plate has been developed, and as the steepest part of the curve is the straight-line part corresponding to correct exposure, it is the slope in this region that is taken for measurement.

To find a figure for the slope it is only necessary to find the increase in density that corresponds to an increase of 1 in log E. At log E=2·47 the density is shown in Fig. 3 as 1·0, while at log E=3·47 it is 1·90. The slope of the curve is thus 0·90. This figure is always referred to by the Greek letter γ (gamma).

The relation of this figure to practical work can most easily

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be seen by considering a photograph including two objects one of which reflects ten times as much light as the other. If the negative is so developed that when it is held up to the light one of the images transmits ten times as much light as the other, the negative may very fairly be described as having the same contrast as the subject. A curve taken from this negative would have a gamma of 1, and we may consequently regard the gamma of a negative as showing how its contrast compares with that of the original subject.

The gamma of a correctly-exposed negative depends upon the developer used, the temperature of development, and the time during which the developer is allowed to act. From a set of curves such as that of Fig. 2 it is possible, by determining the value of gamma from each curve, to find the relationship between gamma and development time, the other factors being of course held constant. A curve showing the increase of gamma with time is given as an inset to Fig. 2, and it will be seen that though at first the rise in contrast is considerable, at longer development times gamma increases but slowly as development is prolonged.

Eventually a value of gamma is reached—in this case apparently about 1·1—which cannot be increased no matter how long a development time is given. This figure for gamma marks the maximum contrast that the emulsion will attain, and since it corresponds to infinitely long development, it is called " gamma infinity " ($\gamma \infty$).

A curve relating gamma to development time is often useful in practice, because the photographer does not necessarily wish to develop all his negatives, irrespective of subject, to the same gamma. Instead, he may try to develop them all to the same contrast, increasing the development time when the subject was flat, or decreasing it if the subject was contrasty. By thus varying gamma to compensate for varying contrast in the subject he is able to keep his negatives more nearly alike in character. As the actual contrast of the subject is seldom known with any precision, the practical photographer can only hope to make an approximate correction by shrewd guesswork.

What is " Correct " Exposure?

Until fairly recently it was conventionally considered, theoretically at least, that the negative should show correct tonal values, which implies that the exposure should be such

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that the deepest shadow should receive an exposure falling on the straight part of the curve. It is in conformity with this view that the toe of the curve in fig. 3 is marked " region of underexposure." Not long before the war, however, it was established that in practice it was perfectly permissible to expose so that the deepest shadow falls well down on the toe of the curve; at a point, in fact, where the slope is a little less than one-third of gamma. Increasing exposure to put the deepest shadow at the bottom of the straight-line portion made no improvement detectable in the final print.

The least exposure that will lead to a good print is therefore one so timed that the deepest shadow falls at a point on the curve when the slope is nearly one-third of gamma—in Fig. 3, at about the point marked " DIN." This is usually referred to as the *minimum correct exposure*. If less is given, shadow-contrast becomes too low and shadow-detail ceases to register.

The effect of increasing the exposure above the minimum is shown by the curve not to be serious. If we have a subject of contrast range 1:32, and expose it so that the deepest shadow falls at A, then the brightest highlight will fall at B. Corresponding densities are 0·6 and 1·9, giving a difference of 1·3. If the exposure is now increased ten times, so that shadows and highlights fall respectively at A_1 and B_1 their respective densities will be 1·5 and 2·8—again a difference of 1·3. At every point, this negative will have a density greater by 0·9 than that at the corresponding point of the first negative. This means that it stops eight times as much light, but if given a printing exposure eight times as long, a print from it will be identical with a print from the first negative. Both these negatives, both of which correspond to exposures above the minimum correct exposures, must therefore be regarded, sensitometrically at least, as correctly exposed.

But it should be noted that if the subject had a longer brightness range, or the film a shorter straight section to its curve, the part B might easily overrun B_2, giving true over-exposure characterized by flattened contrast in the highlights. This is particularly liable to happen on the modern thin-emulsion films, curves of which have quite a short straight-line section.

It is clear that there is not just one " correct " exposure, as is so widely believed, but that exposures considerably in excess of the minimum correct exposure may safely be given. This fact, indeed, explains the success of box and other simple cameras with which, using a single shutter-speed and stop, the

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snapshotter obtains negatives that are at least printable from exposures on quite a wide range of subjects.

Nevertheless, although a sensitometric curve does not show them, there are disadvantages in exceeding the minimum correct exposure; irradiation (*q.v.*) causes the image to spread, so lessening sharpness, and the longer exposure increases the graininess of the image. Neither of these matters to the box-camera user, who normally makes small prints from comparatively large negatives, but they do matter a great deal to the miniature-camera user who wishes to make enlargements of whole-plate size or over from his small negatives.

For the discerning photographer, therefore, the best possible exposure is the minimum correct exposure.

Emulsion Speeds

It is too commonly assumed that the " speed " of a plate or film is as definite and easily measurable a quantity as, say, the speed of a moving vehicle. Nothing could be further from the truth. We have just seen that the minimum exposure required in any particular case depends on the printing paper to be used—so, therefore, does the speed of the negative emulsion. It also depends on the developer chosen, on the extent to which development is to be carried (gamma value to be reached), and the temperature of development.

These are factors that have to be considered when determining the minimum exposure needed in actually photographing some particular subject. In practice, however, emulsion speeds cannot be determined in any but the roughest way by merely taking photographs with a camera; the conditions are not capable of being reproduced, or even stated, with anything like sufficient precision. Speed-measurements, therefore, have to be based on accurate laboratory work; that is, they are based on the characteristic curve of the emulsion. The question at once arises: what part or property of the curve is to be taken as a measure of emulsion-speed? Different workers have answered this query, which is more perplexing even than it appears at first sight, in various different ways; each choice of a criterion of " speed " gives rise to a different speed-system. And it is particularly to be noted that two plates that have the same speed when measured according to one method may have quite different speeds when measured by another.

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H & D Speeds.

The first scientific method of measuring emulsion speed was that of Hurter & Driffield. They ignored any effect of the printing paper, and laid down that the minimum correct exposure was the least that would give accurate tone-reproduction in the negative. They based their film-speed, fundamentally at least, on the point A of Fig. 3. But partly owing to the difficulty in determining the exact point at which the " toe " of the curve began, and partly to find a speed-value that did not greatly depend on gamma, they continued the straight line part of the curve backwards as shown dotted in Fig. 3, and took as a measure of the H & D speed the exposure indicated at the point where this extension cut the line indicating fog-level. This exposure they called the " inertia " ; the speed-number was found by dividing the value of the inertia into 34. Thus the H & D speed numbers are inversely proportional to the exposure required ; a plate of speed 250 H & D requires ten times the exposure needed by a plate of 2500 H & D.

It is now known, firstly, that Hurter and Driffield's conviction that there must be an absolute speed number, independent of the degree of development, was quite unjustifiable, and secondly that, because of the modifying effect of the printing paper, the H & D speed number of an emulsion is by no means a reliable guide to the exposure needed in practice.

Scheiner and DIN Speeds.

The Scheiner system of speed-measurement was introduced, a few years after the H & D system, as a method of comparing the speeds of plates used for astronomical photography. In detecting a star by photography the conception of true tonal rendering does not enter ; Professor Scheiner (1894) therefore rated the speed of a plate by the least exposure that would give a visible darkening on development, which was the point that mattered for his purpose.

In measuring the speed of a plate by the Scheiner method, a series of exposures is given to a light of known intensity, and the plate is then developed under standard conditions. From examination of the developed plate is found the exposure that produces an image just detectable in comparison with the part of the plate that was protected from light. The speed so determined is arbitrarily expressed in " degrees," the

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system being so arranged that each addition of 3 to the Scheiner number corresponds to a doubling of speed.

The original DIN system (Germany, 1931) was a variant of the same idea. For this the emulsion to be tested was exposed for 1/40 sec. behind a neutral scale of densities so arranged that each successive density was greater than the last by 0·1. This scale received a standard illumination of 40 lux. After development, the speed of the emulsion was stated as the density of the scale behind which there had been obtained a density of 0·1 above fog level. Development time was that which gave the highest speed-number; in practice, this meant that development was prolonged considerably beyond the normal. As in the Scheiner system, the speed figures were on a logarithmic scale, and were expressed as " tenths." An emulsion of 18/10 DIN therefore required double the exposure of one rated at 21/10 DIN.

The DIN system has recently been modified in several respects, of which the most important is the standardization of development time to that normal for an average roll film. There still remains the slight weakness that this time is likely to be on the long side for a slow film, which usually develops fast, and on the short side for a fast film. There is consequently a tendency to rate a slow film too high, and a fast one too low. The " tenths " have now been dropped, and speeds are written as 21° DIN, the degree sign conventionally indicating a logarithmic progression of speed figures.

Three Methods Compared.

The three points used in determining H & D, Scheiner, and DIN speeds are marked on Fig. 3. If all characteristic curves had exactly the same shape, and if all emulsions responded in the same way to the prolonged development of the DIN system, it would not matter by which method the speed of an emulsion were determined, because there would be a fixed relationship between them all. A speed found by one method could be converted, by a simple calculation, into a corresponding speed on either of the other systems.

In fact this desirable simplicity is not attained. Different emulsions have curves of different shapes, and they vary in particular in the length of the toe, or under-exposure region. It is quite evident that if the toe of the solid-line curve in Fig. 3 were changed to that shown dotted, DIN and Scheiner speeds would rise very considerably while the H & D speed

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would remain unaltered. There can thus be no fixed relationship between the H & D speed of an emulsion and the DIN or Scheiner speed, though these two are fairly closely related.

The H & D and Scheiner systems are now obsolete, but the later DIN system is current in Germany and most other Continental countries, and consequently a DIN speed number appears on the packet of most Continental films. A few makers, notably Gevaert, still adhere to Scheiner speed-figures in the nomenclature of their films, though probably the original Scheiner test is not used. Thus Gevapan 36 has a speed of 36° Sch., corresponding to a DIN figure ten degrees lower—26° DIN. Other makers use DIN figures in the same way; Adox KB17 has a speed of 17° DIN. Some standardization would be welcome here.

British and American Systems.

In 1947 the first British Standard on determining film speed, closely following an American Standard of a year or two earlier, was published. Both were based, not on the minimum negative density that could be permitted in the shadows, but on the minimum slope that could be accepted without noticeable fall-off in shadow contrast. These two standards were based on research by Loyd A. Jones (*J. Franklin Inst.*, **227** (1939), pp. 297–354 and 497–544.)

This line of approach was to make a series of negatives, all receiving different exposures, upon each of a number of films with emulsions of types as different as could be found; to make the best possible print from each negative, and find in each case the minimum negative exposure necessary to yield a good print. To ensure constancy of conditions, the negatives were not made by exposure in the camera, but by contact printing from a transparency, using a light held rigidly constant.

Next the characteristic curves of all the negative emulsions were measured, and these curves were analysed to find some characteristic property, or relationship, that varied, over the whole range of different emulsion-types, in the same way as the speed found by these laborious experiments. It will be observed that this approach to the problem for the first time provides a method that makes allowance for any correcting effect on shadow gradation brought about by the printing paper.

As all practical photographers know, the beginnings of

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under-exposure are made manifest by a falling-off in contrast in the shadow regions of the picture. In terms of the curve, this means that the shadows fall on a part of the curve whose slope is too low to give adequate contrast. Since the *actual* minimum slope of the part of the characteristic curve used is unimportant for print making—for papers of all grades of contrast are available—it is not feasible to specify the speed by a measurement of the exposure needed to give any specified minimum slope. But it might very reasonably be measured in terms of the exposure required to give a slope which is a specified proportion of the slope elsewhere on the curve. Loyd Jones proposed to take as a criterion of emulsion speed the exposure corresponding to that point on the curve at which the slope is three-tenths of the average slope over a log-exposure range, beginning at the point in question, of 1·5. Jones has shown that this method of measurement gives results agreeing exceedingly closely with those obtained by the examination of prints made in the manner described above, and this criterion was adopted in the British and American Standards already mentioned.

New Standards.

Since 1947 there has been unanimity between Britain and America, so producing uniformity in speed-figures throughout the English-speaking world. But the DIN system remains the Continental standard. As a step towards full international agreement on a world-wide system of speed measurement, the American Standard has been re-formulated, and at the time of writing it is confidently expected that a parallel British Standard will appear very shortly.

The new American Standard follows the DIN specification in that the exposure upon which the speed is based is that yielding, after development, a density of 0·1 above fog, but development, instead of being for a fixed time, as in the DIN and earlier Anglo-American Standards, is carried on so as to achieve a fixed contrast. Experience has shown that if development is controlled in this way the speed-figure obtained is substantially the same as that given by the earlier (and really preferable) minimum-gradient method. Development is correct for speed-measurement when a point on the curve corresponding to 20 times the exposure at the point where the density of 0·1 above fog was recorded shows a density of 0·9 above fog. This implies a gamma of about 0·7, which

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corresponds very closely to the gamma aimed at in most practical photography.

When the speed of an emulsion has been measured as described, it can be expressed in any one of several ways for practical use. The old American Standard, and the presumably obsolescent British one, provided for both arithmetical and logarithmic speed-numbers, the former corresponding to the H & D number already described, and the latter to the Scheiner or DIN system. In America the logarithmic scale has never been popular, and it is omitted from the new Standard. In Britain the logarithmic number began to be used as a replacement for the once widely used Scheiner numbers (the actual figures were almost identical), and for a time A.S.A. (American Standards Association) was used as a prefix to an arithmetical speed-number, and B.S. (British Standard) as a prefix to a logarithmic one, the use of either prefix indicating that the speed had been measured by the joint Anglo-American minimum-gradient method. In the last few years, however, British amateurs have swung over very heavily towards the use of the A.S.A. arithmetical speed-numbers, partly, no doubt, because this system is used in conjunction with the majority of exposure-meters. Consequently it seems probable the logarithmic figures will be discarded in the expected British Standard too.

There are Standards for exposure tables and exposure-meters, and these are so designed as to give a " safety factor " of about $2\frac{1}{2}$—that is to say, the exposure indicated by these tables or meters is about $2\frac{1}{2}$ times the minimum correct exposure, which we have seen also to be the ideal exposure. This safety factor was included in order to be sure that the proportion of negatives spoilt by underexposure should be as small as possible, even though some negatives might receive very full exposure indeed. At the time these Standards were arrived at the miniature camera was used mainly by advanced photographers, so that it would be chiefly the user of a large camera who would follow his exposure meter blindly, and, as we have seen, too full an exposure does not matter much with large negatives. Since then the popularity of the miniature has increased so greatly that now even comparative beginners use it, and experience has shown that, with reversal colour film, which has very little exposure-latitude indeed, even the beginner need expect very few failures indeed if he follows his meter. Consequently the safety-factor is no longer considered desirable. The logical way to remove the safety-factor would

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be by revising all exposure tables and re-scaling all exposure meters, but as this is manifestly impracticable, the new American Standard (and presumably the expected new British one) doubles the speed-number of every film, which, of course, has exactly the same effect.

Those who have already established a routine of exposure and development that gives them the kind of negative they want need not be perturbed by this change; as long as they continue to use the same film, they should go on exactly as before. But those trying a new film should expose it according to the new speed-number for their first trials, modifying the speed-number only if the negatives prove to have had more or less than the minimum correct exposure.

The new American Standard contains yet another innovation; a proposal that film speeds should be expressed as " speed values." The units here are logarithmic, each increase of one unit corresponding to a doubling of film-speed. The speed value is one component of a proposed new method of calculating exposures, and derives from the exposure-value scale introduced on German shutters in 1954. The basis of it is the recognition that if film-speeds are represented by suitable numbers, and the scale over which the needle of the exposure meter moves is suitably graduated, the sum of the light-value (from the meter) and the speed-value of the film can be made to add up to the required exposure-value as marked on the shutter. Further, if shutter-speeds and stops cannot be coupled (as in a focal-plane camera with interchangeable lenses) their respective scales can be marked with time-values and stop-values so chosen that they add up to give the exposure-value. The adoption of this system would simplify the meter by dispensing with all calculating scales, their work being done by simple addition of small numbers.

Until suitably graduated exposure-meters make their appearance, this new scheme will have no practical application.

Table I gives the equivalence between A.S.A. and DIN speed numbers, the A.S.A. figures being the new doubled ones, expected to be operative by the time this edition is published. B.S. doubled figures are also given, together with the new " speed-values."

A.S.A. 50 corresponds to a slow high-resolution film, A.S.A. 400 to the fastest film meant for general purpose work. Films faster than A.S.A. 400 are of the type used for difficult " available light " photography; films slower than A.S.A. 50 for copying and similar specialized purposes.

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Conversions between the Older Systems.

Though, as we have seen, there is no possibility of precise conversions between the Scheiner, H & D and A.S.A. speeds, Table II will serve as a guide to those having tables or meters scaled in one of the older systems, or who are reading some of the older photographic literature.

TABLE I.—A.S.A. AND DIN SPEED NUMBERS

A.S.A. (Weston)	DIN (Degrees)	Speed Value	B.S. (Obsolescent) (Degrees)
3	3	0	16
6	6	1	19
12	9	2	22
25	12	3	25
50	15	4	28
100	18	5	31
200	21	6	34
400	24	7	37
800	27	8	40
1,600	30	9	43
3,200	33	10	46

TABLE II.—CONVERSION SPEEDS

A.S.A. (new)	Scheiner	H & D	Weston (old)	G.E.	Watkins	Wynne
3	14	35	1·2	1·5	65	F/53
6	17	70	2·5	3	130	F/74
12	20	140	5	6	250	F/105
25	23	280	10	12	500	F/150
50	26	560	20	25	1,000	F/210
100	29	1,100	40	50	2,000	F/300
200	32	2,200	80	100	4,000	F/420
400	35	4,400	160	200	8,000	F/600
800	38	9,800	320	400	16,000	F/850
1,600	41	20,000	640	800	32,000	F/1200
3,200	44	40,000	1,280	1,600	64,000	F/1700

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These comparisons, though they have behind them the highest authority, are nevertheless approximate; in 1914, when H & D and Watkins speeds were those most used, a popular plate was rated at 270 H & D or 180 Watkins. Continental manufacturers quoted H & D speeds about three times higher than would have been allotted to the same emulsion in Britain and U.S.A.; American Scheiner figures were five or six units lower than British and Continental ones.

For Further Study.

An excellent introductory book on sensitometry is *Sensitometry*, by Lobel and Dubois (Focal Press), a translation of a French work that has been accepted as authoritative for a number of years. A clear exposition of fundamental principles will also be found in *Perfect Negatives*, by Glover and Wakefield (Fountain Press). The latest advances, in theory and equipment, are fully discussed in *The Theory of the Photographic Process*, by C. E. K. Mees.

Variation of Gamma to Compensate for Contrast of Subject.

For constant difference between highest and lowest densities, in a series of negatives in which maximum and minimum exposures bear different ratios to one another, each negative must be individually developed to a gamma inversely proportional to the logarithm of the ratio of maximum to minimum exposure. A set of negatives with development carried out according to this rule would all yield full-scale prints, running from brilliant (but not blank) high lights to full (but not blocked-up) shadows, on the same grade of paper, no matter how great or small the original contrast of the subject might have been.

Separation Negatives. See COLOUR PHOTOGRAPHY.

Sepia Paper. An iron-silver process akin to kallitype (*q.v.*), of which it may be regarded as a simple form. It is mainly used for making paper negatives from engineers' drawings, blue prints being made in turn from these. The process may, however, also be used for making ordinary prints, and is particularly valuable for the local sensitising of menus, Christmas cards, and the like that are to have a design or photograph reproduced upon them.

The following mixture may be used to sensitise writing paper, Bristol board, and other such surfaces.

Prepare :—

A. Ferric ammonium citrate (green) . . .	10 gm.	(88 gr.)
Water to . . .	100 c.c.	(2 oz.)

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B. Silver nitrate . . .	14 gm.	(122 gr.)
Water to .	60 to 80 c.c.	(9½ to 13 dr.)

To *B.*, add ammonia drop by drop till the precipitate first formed disappears. At this stage the solution should not smell of ammonia; if it does, add a dilute solution of citric or sulphuric acid drop by drop till the smell just vanishes. Mix *A* and *B* in weak artificial light, and keep in the dark.

Apply, either as it stands or with the addition of a little freshly made arrowroot or starch paste, with a brush (which must have no metal parts) to the surface to be sensitised. This must be done in weak artificial light; leave to dry in the dark. The prepared paper will keep for several days.

Print by bright daylight until the image is a little stronger than will finally be required, then fix in 4 per cent. hypo containing also 1 to 2 per cent. of anhydrous sodium sulphite (2 to 4 per cent. of crystals). After 5 minutes fixing, wash thoroughly and dry. The sepia tone may be modified, if desired, by toning with gold. (See TONING; and refer also to KALLITYPE.)

Sepia Toning. See TONING.

Sheet Film. An alternative name for cut film (*q.v.*).

Shellac. See VARNISH.

Short Stop. American term for "stop-bath" (*q.v.*).

Shutter. An automatic device that allows light from the lens to act on the sensitive emulsion for a predetermined period to make the exposure. At the present time there are only two types of shutter in general use; the between-lens or diaphragm shutter such as the Compur, and the focal-plane shutter.

The diaphragm shutter consists of a body, usually circular in outline, through the centre of which there is a circular opening equal in diameter to the lens. The two component parts of the lens, consisting of glasses or combinations of glasses mounted in metal cells, are screwed over front and back of the opening, so that the shutter-body takes the place of the usual tubular lens-mount. Besides the iris diaphragm, the space between the two halves of the lens contains the shutter-blades, thin leaves of metal overlapping so as to close the central opening. These are so pivoted as to turn back into the outer casing when the shutter is operated, so that the shutter opens from and closes to the centre of the lens.

In the simplest types only two blades are used, and the spring that drives the shutter is compressed as the release-lever is depressed. Since no separate "setting" or "cocking"

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action is needed, these shutters are often described as "everset." They generally have a limited range of speeds, these often depending on nothing more than variations in the tension of the driving-spring, and they begin to close the instant they are fully open.

More elaborate shutters have two distinct movements for opening and closing, each of which acts takes place in the shortest possible time. For the highest speed there is no interval between the completion of opening and the beginning of closing, but for all lower speeds a clockwork brake is brought into action to delay the commencement of closing. There is thus a definite period, increasing as the speed is made slower, during which the shutter is held fully open. A shutter such as this may be speeded from 1 sec. to 1/500th of a sec., with an efficiency varying from practically 100 per cent. at the slowest speed to a little over 50 per cent. at the fastest. Higher efficiency is, of course, obtained if the shutter opening is larger than the lens opening, as it is when the lens is stopped down. Power for operating this complex mechanism is derived from a spring, which has to be tensioned before each exposure either by means of a setting lever or by a linkage to the film-wind mechanism. The pressure required to release the shutter is usually very light.

The basic shutter just described has been greatly elaborated of late years. The first addition was flash contacts, the operation of which is discussed under FLASHGUN. Then, in 1954, appeared the exposure-value shutter, in which stop and speed scales are mechanically linked in such a way that as the shutter speed is raised or lowered the stop is opened or closed to keep unchanged the amount of light reaching the film. A scale indicates the exposure-value that corresponds to all these possible combinations. To change the exposure-value, the linkage is temporarily broken by depressing a catch, when stop or shutter speed, or both, can be independently adjusted to give a new exposure-value.

Further elaboration is required in the shutters used for single-lens reflexes. They have to stay open, with the lens at full aperture for focusing, and when the release is pressed the shutter closes, the lens-aperture closes down to a pre-set value, then the mirror is released and the exposure made.

Still further complexities arise when a built-in exposure meter is coupled to the shutter so that speed, stop, or both are controlled by the indications of the meter, either directly or through intervention by the user, this taking the form of

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turning a control to bring the needle of the meter to a fixed point, or a movable pointer to the needle.

Focal plane shutters are so named because they work near the focal plane. An opaque blind, in which there is an opening or slit, is wound by springs from one roller to another across the sensitive surface. Exposure is determined by the width of the slit and the rapidity of its passage. Modern shutters are in most cases *self-capping*, by which is meant that the slit is covered as the shutter is wound up ready for the exposure ; it is therefore not necessary to " cap " or cover the lens to prevent fogging the film. Variable slit-width is obtained by using two blinds, the relative position of which is controlled by the speed-adjusting mechanism.

The focal-plane shutter has the valuable feature that by using a narrow slit the exposure may be made very short (1/5000th of a sec. has been achieved in a practical camera) while so long as the slit is very close to the film the efficiency remains extremely high. If the slit is far from the film the efficiency at high speeds is, on the contrary, very low ; in some cameras the film-to-shutter distance is far too large to justify claims for any but the most modest efficiency.

The focal-plane shutter has the special advantage that as it is in no way concerned with the lens, any camera fitted with it can quite readily be equipped to take interchangeable lenses of different focal lengths. Further, it lends itself to the type of design in which the shutter is wound, and the film advanced, by a single action, and makes it easy to have a comfortably accessible release on the body of the camera.

To set against these merits, the fact that it exposes the film piecemeal involves distortion when a moving object is photographed ; the familiar oval wheels of a racing car are a typical example. If the image is moving from right to left over the film, then a blind travelling also from right to left will elongate the image in the direction of its motion, one travelling from left to right will shorten it, a blind travelling down will incline the image forwards, and one travelling up will incline it backwards. (The image is upside down.) The higher the velocity of the blind the less the distortion ; where slit-width and spring-tension are independently adjustable, the highest tension should always be used for moving objects.

Older focal plane cameras often had this separate adjustment of slit and tension, the speed corresponding to any combination of the two being read off from an engraved table attached to the camera. In most of these tables the effect of spring-

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tension was grossly over-rated ; it is rare for a change from the lowest to the highest tension even to double the speed obtained. A rough approximation to true shutter speeds on such cameras may be had by reckoning that a slit 25 mm., or 1 inch, wide gives an exposure of 1/60th sec., at the lowest tension and 1/90th sec., at the highest. For slits of other widths, the effective exposure (light action on plate) is proportional to slit-width.

The blinds of a focal-plane shutter are usually of rubberized cloth, and in time the rubber perishes, leaving pinholes that allow light to reach, and fog, the plate before or after exposure. These pinholes, if not too bad, can be filled in by treating the blind with any opaque and flexible paint. Rubber solution into which lamp-black has been worked, or the black rubbery composition used for fixing rubber soles to shoes, will often be found effective. The following has also been recommended :—

Artists lamp-black powder . .	1 part by volume
Flexile collodion . . .	4 parts by volume
Ether	4 parts by volume

Stir well before use, and keep in a well corked bottle in a cool place. Dries quickly with matt black surface.

Brush rapidly over the fabric side of the blind, using an artist's round brush of suitable size. Speed in applying is essential, and do not go over the same surface twice with the brush.

In many cases, however, it will be found necessary to fit new blinds, which is a fairly simple matter.

Time and Bulb.—In addition to giving a range of automatically-controlled speeds, every shutter is so made that it can be opened for an indefinite period. This is required for prolonged exposures on interiors, and also for viewing the image on a focusing screen if one is used. At the setting marked " T " or " Z " a shutter opens at one pressure on the release, and remains open till this is pressed a second time. At the setting marked " B," pressure on the release opens it, but it closes again as soon as the pressure ceases. Modern cameras in which the release, after once being depressed, is locked until the film has been wound on, are often not fitted with a " T " setting for the shutter ; in these cases the shutter can be held open for prolonged exposures at the " B " setting by a catch engaging the release-trigger and holding it down, or by a corresponding device attached to the wire release.

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Older Types of Shutter.

The Roller-Blind Shutter.—Of older shutters, the only one still used to any extent is the roller-blind shutter, which still finds a place on stand cameras. It consists of a blind, with a fixed aperture, built into a wooden casing fitted either behind or in front of the lens. By varying the tension, speeds nominally ranging from 1/15th to 1/90th of a sec. can be obtained. For longer exposures, a " Time-valve " on the pneumatic release (*q.v.*) can give a range from 1/8th of a sec. to 1 sec. or more by controlling the rate of leakage of air from the release.

The Drop Shutter, now obsolete, was similar in principle to the roller-blind shutter, but in this a piece of wood or metal, falling either by its own weight or accelerated by rubber bands, took the place of the blind.

The Rotary Shutter, a metal plate with an opening in it that is so mounted as to rotate across the front of the lens, is still used in some inexpensive box-form cameras.

The Foreground Shutter, situated in front of the lens, consisted of a hinged flap that opened upwards and closed downwards, so giving the foreground more exposure than the sky. It was generally opened by pressure on a bulb, and closed by release of that pressure, and so would give no exposure shorter than about 1/8th of a sec.

The Flap Shutter was similar to the foreground shutter, but often consisted of two flaps opening outwards to give even exposure to all parts of the image.

Accuracy of Speed-Markings.

British Standard 1592/1958 lays down the accuracy with which the effective exposure times (see SHUTTER EFFICIENCY) must correspond with the times marked. For diaphragm-type shutters, the permitted error is plus or minus 20 per cent. for exposure times of 1/100 sec. or longer, plus or minus 30 per cent. for shorter times. In the case of focal-plane shutters, permitted error is plus or minus 25 per cent. for exposure times of 1/250 sec. and longer, plus or minus 33 per cent. for shorter times.

Shutter Efficiency. A diaphragm shutter of any type takes some more or less definite time to achieve full opening, during which time the lens is effectively stopped down. The same effect recurs as the shutter closes.

If such a shutter is so set as to give a total exposure of 1/100th of a sec. (measured from beginning of opening to finish of closing) the amount of light reaching the film will be

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appreciably less than if the shutter had opened instantaneously, remained fully open for 1/100th of a sec., and closed again instantaneously. The amount of light passed during the exposure, expressed as a fraction of the amount that would have been passed by a theoretically perfect instrument (instantaneous opening and closing), is called the efficiency of the shutter.

The question of efficiency arises in its most acute form when the photography of moving objects is attempted. If the object is brightly lighted, it will leave a trace on the film during all parts of the total exposure time, including that for which the lens is only partly open. If the total time of exposure is 1/100th of a sec., and the efficiency of the shutter at that setting is 0·5, or 50 per cent., the amount of movement shown on the film will be that corresponding to 1/100th of a sec. exposure, but the amount of light-action will be only that corresponding to an exposure of 1/200th of a sec. This latter figure is the effective exposure time, and for purposes of exposure calculation the effective exposure should correspond to the marking on the speed-scale of the shutter. As can be seen, an inefficient shutter accentuates the ever-present difficulty of combining adequate light-action on the film with a shutter-speed fast enough to arrest motion.

In the case of any gear-controlled shutter that opens rapidly, stays open for a period, and then closes rapidly, the efficiency may be assumed to vary from practically 100 per cent. for exposures of 1 sec. to not much more than 50 per cent. at its highest speed.

Efficiencies less than 100 per cent. are not peculiar to the diaphragm shutter. If the slit of a focal-plane shutter were actually in contact with the sensitive surface, it would have an efficiency of 100 per cent. at all speeds. In practice, however, the slit is often some way from the film or plate—especially in the older cameras built of wood and fitted with a revolving back—with the result that on the higher speeds the efficiency may be very low. This arises owing to the blurring of the shadow thrown by the edge of the slit, so that as the slit reaches any point on the plate the latter passes only slowly—not instantaneously—from darkness to light, and *vice versa* as the slit passes away again.

The numerical value of the efficiency can be found very readily by simple measurement of the slit-width w and film-to-blind distance d, and is given by the formula :—

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$$\text{Efficiency} = \frac{wn}{wn+d}, \text{where } n = f/\text{number of lens-aperture.}$$

For example, a shutter used with an $f/3{\cdot}5$ lens, set to a slit-width of $\frac{1}{10}$ in., and operating 1 in. from the film, will have an efficiency of—

$$\frac{\frac{1}{10} \times 3{\cdot}5}{(\frac{1}{10} \times 3{\cdot}5)+1} = \frac{0{\cdot}35}{1{\cdot}35} = 0{\cdot}26, \text{ or } 26 \text{ per cent.}$$

If, as is probable, this narrow slit corresponds with an exposure marked as 1/1000th of a sec., there is not unnaturally some doubt as to what the marked figure really means. In most cases it should be interpreted as meaning that the quantity of light reaching the film will be equal to that passed in 1/1000th second by a theoretically perfect shutter. The total time of opening, from the moment when a point on the plate first begins to receive light until the moment when it is again in complete darkness, will therefore be 1/260th of a sec. in the case under discussion.

British Standard 1592/1958 stipulates that both diaphragm and focal plane shutters shall have an efficiency not less than 60 per cent. at all speeds.

Shutter Releases. In most modern cameras a plunger release on the body of the camera is used, this either acting direct on a focal-plane shutter or by means of a more or less complicated mechanical linkage on the trigger of a diaphragm shutter. Where the camera is to be used on a stand, and so cannot be touched to release the shutter, a wire release is used. This consists of a steel wire inside a fabric casing ; the latter is screwed to the shutter, and on pressing a plunger the wire is pushed through the casing, so operating the shutter. (See also PNEUMATIC RELEASE, DELAYED ACTION.)

Shutter Speed Testing. To determine the speeds of a shutter an object moving at a known speed is photographed, and the displacement of the image on the negative is measured. It is generally most convenient to use a rotating object ; bicycle wheels, gramophone turn-tables, and synchronous electric motors (as in a synchronous electric clock) have all been used. It is usually best to affix a small convex mirror, or a silvered ball of the kind used for decorating a Christmas tree, to the rim of the rotating disc ; by working in direct sunlight this reflects a point of light sufficiently brilliant to record distinctly on the negative. If, for example, the rotation is at the rate of five revolutions per sec., and the negative shows a

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blurred image covering an angle of 30°, the total exposure-time was 1/60th of a sec. (30° is 1/12th of a circle, and a complete circle is made in 1/5th sec.; exposure was therefore 1/12th of 1/5th, or 1/60th of a sec.)

Another method is to focus a point source of light on the edge of a wheel (gramophone turn-table, etc.) and to place the shutter where it can intercept the beam. In a darkened room, wrap a long strip of bromide paper round the wheel, set it rotating at a known speed, and release the shutter. The length of the trace of light on the developed paper shows the duration of the exposure. This method, unlike that based on photographing a rotating wheel, is applicable to focal-plane shutters, though it is necessary to ensure that the direction of travel of the blind is at right-angles to the plane of the wheel round which the strip of paper is wrapped.

Except by a falling-off of brilliance towards the end of the trace left by the moving point of light, no indication of shutter efficiency is given by either of these tests.

Those concerned with the research and development work involved in designing a shutter use much more elaborate methods, involving a vacuum photocell to receive the light passed by the shutter and a cathode ray oscillograph as an indicator. By this means a curve showing the light passed by the shutter at every instant during the time it is open is automatically and instantaneously produced. For details of such an equipment, see *Photographic Journal*, Sect. B, Sept.–Oct., 1946.

Silhouettes, Photographic. The sitter is placed against a thin white screen, such as a sheet strongly illuminated from behind; an excellent plan being to stretch the screen over the doorway of a passage in which the camera is placed. The following points should be observed :—

1. No light should enter the room by other windows or doors than the one under operation.

2. There should be no objects outside this window or door close enough to cast a shadow.

3. The sitter's head should be focused as sharply as possible so as to present the appearance of a silhouetted profile on the screen.

4. The exposure should be too short to give any detail at all on the shadow side of the sitter, and development should be prolonged to give maximum contrast. If exposure has been cut too fine, the negative may be intensified to give sufficient contrast.

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Silk, Printing on. Many photographic processes are applicable to silk and other textiles; for example, the direct blue print process (see CYANOTYPE), and practically all silver processes which do not involve the use of a definite colloid coating or film, although a trace of gelatine as a sizing agent is often useful. The following is applicable to silk, muslin, linen, or canvas :—

Water	10 oz.	(500 c.c.)
Common salt. . . .	100 gr.	(11·5 gm.)
Gelatine	20 gr.	(2·3 gm.)

Dissolve with heat and uniformly moisten the textile, which may be conveniently stretched on a frame. When dry, moisten with a 9 per cent. solution of silver nitrate. The material being once more dry is ready for printing. Toning and fixing as for prints on albumenised paper. (See TONING.)

For making enlargements on canvas see CANVAS, and for dyeing processes on textiles see DIAZOTYPE PROCESS. (See also CARBON PROCESS.)

Silver Bromide (Fr., *Bromure d'argent;* Ital., *Bromuro d'argento;* Ger., *Bromsilber.*) AgBr = 188. Is darkened to a tawny grey by the prolonged action of light, with evolution of bromine. It is practically insoluble in water, alcohol, and ether, but soluble in solutions of alkaline thiosulphates, cyanides, thiocyanates, ammonia (about 1 : 1000), and saturated solutions of most chlorides, bromides, and iodides. Silver bromide, either alone or mixed with iodide and chloride, is the usual sensitive salt in emulsions.

Silver Chloride (Fr., *Chlorure d'argent;* Ital., *Cloruro d'argento;* Ger., *Chlorsilber, Silberchlorid*). AgCl = 143·5. On exposure to light when absolutely pure or dry no change takes place; but with the smallest trace of organic matter or water it passes from white through varying shades of purple to black, chlorine being disengaged. It is soluble in solutions of the same salts as the bromide, and also in ammonia—a double salt, ammonio-chloride of silver, being formed. It is used for making lantern-plate and contact emulsions, gelatino-chloride printing-out papers, and is the basis of most home-made printing papers.

Silver Iodide (Fr., *Iodure d'argent;* Ital., *Ioduro d'argento;* Ger., *Jodsilber, Silberjodid*). AgI = 235. Insoluble in water and dilute nitric acid, almost insoluble in ammonia, but

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soluble in all the other salts which dissolve bromide. When prepared by precipitation from a solution of alkaline iodide by adding silver nitrate, the iodide being in excess, the precipitate is white, and less sensitive to light than the yellowish precipitate formed when excess of silver is used. It is used for making emulsions, giving increased sensitivity and great latitude of exposure with great density of image, and is also used in the wet-collodion process.

Silver Nitrate (Fr., *Azotate d'argent ;* Ital., *Azotato d'argento ;* Ger., *Silbernitrat*). $AgNO_3 = 170$. Is prepared from pure silver by solution in nitric acid and subsequent purification and crystallisation. Ordinary commercial nitrate is usually very acid, due to its not being absolutely freed from nitric acid ; but that prepared for photographic purposes should be almost neutral, or at least show only a faint trace of acid. Solubility : 120 parts are soluble in 100 parts of distilled water, 1 in 15 of rectified spirit. When dissolved in common water, a thick curdy-white precipitate of carbonate and chloride of silver is formed. Boiling alcohol dissolves about one-fourth of its weight of silver nitrate, but deposits it on cooling. It is soluble in ammonia, with the formation of a double salt. It is used for sensitising paper, and preparing all, or nearly all, the other salts of silver used in photography. When heated it melts and forms, when poured into moulds, the " lunar caustic " of commerce ; and when heated higher still gives off some oxygen, and a mixture of nitrite ($AgNO_2$) and nitrate of silver ($AgNO_3$) is left. When exposed to the light, either in solution or in a pure dry state, no action takes place ; but on contact with organic matter it darkens through purple to black.

Silver Sulphide (Fr., *Sulfure d'argent ;* Ital., *Solfuro d'argento ;* Ger., *Schwefelsilber*). $Ag_2S = 248$. This salt is met with in residue recovery, and is the resultant salt of the decomposition of thiosulphate of silver in prints. The image in a sulphide-toned print consists of silver sulphide.

Silvering Mirrors. See MIRROR, SILVERING.

Single Transfer. See CARBON PROCESS.

Sizes, Photographic. The sizes used for photographic plates and papers are of traditional rather than systematic origin, and the best-known of them, whole-plate ($8\frac{1}{2} \times 6\frac{1}{2}$ in.), half-plate ($6\frac{1}{2} \times 4\frac{3}{4}$ in.), and quarter-plate ($4\frac{1}{4} \times 3\frac{1}{4}$ in.) are

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very old. A Daguerreotype camera in the Science Museum is fitted with carriers for these three sizes, which must therefore have been in use for well over a hundred years.

Even at that early date, the so-called half-plate size ($6\frac{1}{2} \times 4\frac{3}{4}$) was not the half of a whole-plate, which would be $6\frac{1}{2} \times 4\frac{1}{4}$, but was widened, doubtless to make a more acceptable shape. The original whole-plate being rather square, it naturally cuts to give long and narrow halves.

Most of the other standard sizes—*e.g.*, 10 × 8, 12 × 10—are also rather square, which accounts for the wide range of sizes in use and their lack of relationship to one another. It is worth noting that if the length of a sheet of paper is 1·41 times its width, the same relationship between long and short sides will be maintained if the paper is halved. That is, the two halves will have the same shape as the original sheet. Except 7 × 5in., none of the larger standard sizes approach at all closely to this shape, which is that of a $3\frac{1}{2} \times 2\frac{1}{2}$ plate.

Owing to the fact that it is now quite usual to build cameras designed to make a large number of small pictures on a roll of film originally intended for a smaller number of larger pictures, the compilation of a list of standard negative sizes has become rather complex.

The three sizes of film that have been used in this way are 35-mm. cine film, giving pictures 24 × 36 mm., 24 × 24 mm., and 18 × 24 mm., V.P. film for pictures 4 × 6·5 cm., 4 × 4 cm., and 3 × 4 cm., and $3\frac{1}{4} \times 2\frac{1}{4}$ (6 × 9 cm.) film, used also for pictures 6 × 6 cm. and 4·5 × 6 cm. Of these sizes, by far the most popular are 24 × 36 mm. and 6 × 6 cm. ($2\frac{1}{4}$ in. sq.); probably nine-tenths of all amateur cameras of standard appreciably above that of the holiday-makers' box camera are made to give negatives in one or other of these two sizes.

Table I gives the current negative sizes up to quarter-plate ($3\frac{1}{4} \times 4\frac{1}{4}$ in.), and indicates in each case the negative material used. The sizes marked with an asterisk are in common use; the others are much less often met.

No roll film cameras are any longer made for sizes above $2\frac{1}{4} \times 3\frac{1}{4}$, though films are still available, at the time of writing, for cameras of several larger sizes that have been popular in the past. Cameras for $3\frac{1}{2} \times 2\frac{1}{2}$ or larger sizes are now built exclusively for plates or cut films.

Current sizes for plates and cut films are as shown in Table II, in which inch and centimetre sizes are independent.

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TABLE I.—CURRENT NEGATIVE SIZES

Size. Metric.	Size. Inches.	Material Used.	Exposures per roll.
18 × 24 mm.	($\frac{3}{4}$ × 1)	Standard 35 mm. cine film	66
24 × 24 mm.	(1 × 1)		48[a]
*24 × 36 mm.	(1 × 1$\frac{1}{2}$)		36
28 × 40 mm.	(1$\frac{1}{8}$ × 1$\frac{9}{16}$)	Roll film No. 828	8
3 × 4 cm.	(1$\frac{3}{16}$ × 1$\frac{9}{16}$)	V.P. roll film No. 127 or No. 27	16
*4 × 4 cm.	(1$\frac{9}{16}$ × 1$\frac{9}{16}$)		12
4 × 6·5 cm.	(1$\frac{9}{16}$ × 2$\frac{1}{2}$)		8
4·5 × 6 cm.	(1$\frac{3}{4}$ × 2$\frac{1}{4}$)	3$\frac{1}{4}$ × 2$\frac{1}{4}$ roll film No. 120 or No. 620	16
*6 × 6 cm.	(2$\frac{1}{4}$ × 2$\frac{1}{4}$)		12
(6 × 9 cm.)	2$\frac{1}{4}$ × 3$\frac{1}{4}$		8
4·5 × 6 cm.	(1$\frac{3}{4}$ × 2$\frac{1}{4}$)	Plates	—
*(6·5 × 9)	3$\frac{1}{2}$ × 2$\frac{1}{2}$	Plates	—
(6·5 × 11)	2$\frac{1}{2}$ × 4$\frac{1}{4}$	Roll film 16	8
(8·3 × 10·8)	3$\frac{1}{4}$ × 4$\frac{1}{4}$	Plates	—
(8·3 × 10·8)	3$\frac{1}{4}$ × 4$\frac{1}{4}$	Roll film 18	6

NOTE.—Metric or inch sizes in brackets are nearest convenient equivalent to the true size, which is in all cases that shown without brackets.

TABLE II.—PLATE AND CUT-FILM SIZES

Inches	*Centimetres*	*Equivalent in Inches*
2$\frac{1}{2}$ × 3$\frac{1}{2}$	4·5 × 6	1$\frac{3}{4}$ × 2$\frac{5}{16}$
3$\frac{1}{4}$ × 4$\frac{1}{4}$ ($\frac{1}{4}$-pl)	6·5 × 9	2$\frac{1}{2}$ × 3$\frac{1}{2}$
3$\frac{1}{2}$ × 5	9 × 12	3$\frac{1}{2}$ × 4$\frac{3}{4}$
4 × 6$\frac{1}{2}$ ($\frac{1}{2}$-pl)	10 × 15	3·9 × 5·9
4$\frac{3}{4}$ × 6$\frac{1}{2}$ ($\frac{1}{2}$-pl)	12 × 16·5	4$\frac{3}{4}$ × 6$\frac{1}{2}$
6$\frac{1}{2}$ × 8$\frac{1}{2}$ (whole pl)	13 × 18	5·1 × 7·1
8 × 10	18 × 24	7·1 × 9·4
10 × 12	24 × 30	9·5 × 11·8

PRINTING PAPERS.

To keep the prices of printing paper down, the manufacturers have carried out extensive "rationalization" of sizes and packings, with the result that the number of different sizes in which paper is offered has been greatly reduced, and in addition there is no longer so wide a choice in the number of

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sheets per packet or box. It is specially to be noticed that papers are no longer available in all the existing negative sizes; quarter-plate paper is represented by $3\frac{1}{2} \times 4\frac{1}{2}$ in., as used for "Enprints" (*q.v.*) and the 5×4 in. size has also disappeared. In a number of cases an English (inch) size has been assimilated to the nearest centimetre size, or vice versa.

Standard sizes for printing papers have been agreed by most of the manufacturers supplying the British market and laid down in British Standard 1112/1958. Those larger than $3\frac{1}{2} \times 4\frac{1}{2}$ inches are given in Table III:—

TABLE III.—BRITISH STANDARD PRINTING PAPER SIZES

In.	*Cm.*	*In.*	*Cm.*
$3\frac{1}{2} \times 4\frac{3}{4}$	9 × 12	$7\frac{1}{8} \times 9\frac{1}{2}$	18 × 24
$3\frac{1}{2} \times 5$	8·9 × 12·7	8 × 10	20·3 × 25·4
$3\frac{1}{2} \times 5\frac{1}{2}$	9 × 14	$9\frac{1}{2} \times 11\frac{3}{4}$	24 × 30
$4\frac{1}{8} \times 4\frac{1}{8}$	10·5 × 10·5	10 × 12	25·4 × 30·5
4 × 6	10·5 × 14·8	11 × 14	28 × 35·6
$4\frac{3}{4} \times 6\frac{1}{2}$	12 × 16·5	$11\frac{3}{4} \times 15\frac{3}{4}$	30 × 40
$5\frac{1}{8} \times 5\frac{1}{8}$	13 × 13	12 × 15	30·5 × 38
$5\frac{1}{8} \times 7\frac{1}{8}$	13 × 18	15 × 18	38·1 × 45·7
6 × 8	15·2 × 20·3	16 × 20	40 × 50
$6\frac{1}{2} \times 8\frac{1}{2}$	16·5 × 21·6	20 × 24	50 × 60

For those who wish to cut special sizes, printing papers are available also in rolls, the most usual widths being 20 and 40 inches, with lengths of 25 or 33 feet.

Sketch-Portrait. Term applied to a portrait that has been finished to resemble a pencil sketch. The original print, usually on matt paper, is kept very light, and is often vignetted off to give a pure white surround of large dimensions. Features and clothing are then strengthened as required by pencil work, and the background is given several lines or patches of shading so disposed and executed as to give the impression of a pencil sketch. (See also DRAWINGS FROM PHOTOGRAPHS.)

Skin, Effects of Chemicals on. To some extent the effect of chemicals on the skin is an individual matter, as the finger-tips and nails of some persons seem more easily stained than others. Most are immune to metol poisoning, a few suffer badly from the slightest contact. (See also POISONS.)

Stains.—Pyro and amidol developers are particularly prone

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to stain the fingers, and should be avoided by those who value the appearance of their hands, unless they are prepared to wear rubber gloves or finger-stalls. Paraphenylenediamine and Meritol can both cause stains, particularly if their solutions are allowed to dry on the fingers. It is said that pyro stains can be largely avoided if the fingers are dipped in citric acid solution (5 to 10 per cent.) each time they have been wetted with pyro. M.Q. developer can be used freely without any danger of stains provided the fingers are rinsed frequently. A crystal of citric acid, or a slice of lemon, is quite effective in removing pyro stains, and pumice may also be used.

Metol Poisoning.—The action of metol on the fingers of those few who are susceptible to it results in cracked skin, while the fingers swell till the nails and tips are broken, and spreading sores may follow in other parts of the hand. The effect is sometimes due to the presence in the metol of traces of dimethylparaphenylenediamine as an impurity, and the recognition of this fact has led to vast improvement in the processes used for purifying metol. Poisoning from metol is nowadays not often met.

Those affected should soak the hands in warm water at night, and rub in the following ointment two or three times daily. It should be well rubbed in before retiring for the night.

Ichthyol	1 part
Lanoline	3 parts
Boric acid	4 parts
Vaseline	3 parts

This will ease the sores and effect a rapid cure, but any person once affected becomes more sensitive as a result, and must never allow himself to come into contact with metol again. A plain metol developer can be replaced with fair satisfaction by paraminophenol, and an M.Q. developer by one containing phenidone in place of metol. (See PHENIDONE, DEVELOPMENT and FINE-GRAIN DEVELOPMENT.)

Bichromate Poisoning affects some persons, and is particularly liable to occur if there are any scratches or cuts on the hands. If the fingers itch after being in bichromate solutions, do not scratch them, but apply a soothing ointment, or use the following lotion :—

Glycerine	4 parts
Carbolic acid	1 part
Alcohol	40 parts

If the skin cracks and gets sore, an ointment containing mercury nitrate may be used.

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Bichromate stains may be removed by application of dilute ammonia, followed by washing in warm water and soap.

General.—It should always be borne in mind that though the number of photographic chemicals liable to affect the sound skin, even of susceptible persons, is small, many chemicals may do damage if allowed to come into contact with cuts, sores, or abrasions.

The first and most essential preventive of skin trouble (and indeed of many photographic troubles too) is never to dry fingers wet with solution on a towel, but *always* to rinse the solution away under the tap first.

A very considerable measure of protection can be obtained by the use of special creams (" barrier creams ") which are to be applied to the skin before coming into contact with chemicals. These creams, as their name implies, seal the pores of the skin and so prevent all penetration by the substances handled. For the choice of such creams, a chemist or doctor should be consulted.

Sky-Shade. A flat piece of metal or wood that can be placed at an angle above the lens to shade it from excessive light from the sky. Most often found on the old box-form reflex cameras, where it is usually hinged to the lens panel, and can be closed down over the lens to protect it when the camera is not in use. It is a primitive form of lens-hood (*q.v.*). See also REFLECTION IN LENSES.

Snapshot. Originally a photograph taken at a shutter speed high enough to allow the camera to be hand-held, but now most usually applied to a photograph taken without care or skill, or by a beginner.

Snapshot Photography. See MOVING OBJECTS, PHOTOGRAPHY OF, also HAND-CAMERA WORK and SHUTTER.

Sodium Biborate. See BORAX.

Sodium Bicarbonate (Fr., *Bicarbonate de soude ;* Ital., *Bicarbonato di soda ;* Ger., *Natriumbicarbonat, Doppeltkohlensaures Natron*). $NaHCO_3 = 84$. Synonyms: Acid Carbonate of Soda, Sodium Hydrogen Carbonate. Is prepared by passing carbon dioxide into sodium carbonate moistened with water. Solubility: 1 in 14 of water ; insoluble in alcohol. It is used for toning. It is invariably met with in commerce as a fine impalpable powder, and should not be confounded with the carbonate, which is frequently met with in crystals.

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Sodium Bisulphate. (Fr. *Bisulphate de soude ;* Ital., *Bisolfato di soda ;* Ger., *Natriumbisulfat*). $NaHSO_4 H_2O = 138$. Synonyms : Sodium hydrogen sulphate, Acid sulphate of soda. 100 parts of water dissolve 25 or more parts of the crystals, giving a solution indistinguishable from one containing equal (molecular) parts of neutral sodium sulphate (Glauber's salt) and sulphuric acid. Sodium bisulphate may thus be used, if the presence of sodium sulphate is harmless, as a purer, more readily weighed, and more convenient equivalent of sulphuric acid ; 2·82 parts by weight equal 1 part by weight of the pure acid. It is frequently used in this capacity in prepared acid hardeners and hardening fixers issued in powder form in packets or tins.

Sodium Bisulphite (Fr., *Bisulfite de soude ;* Ger., *Saures Schwefligsaures Natron, Natriumbisulfit*). Synonym : Acid Sulphite of Soda. $NaHSO_3 = 104$. Occurs in fine white crystals. Obtained by passing sulphur dioxide through a solution of sodium carbonate. Used in making acid fixing baths (*q.v.*). If more convenient, each 100 parts of sodium bisulphite may be replaced in all usual applications by 107 parts of potassium metabisulphite (*q.v.*).

Sodium Bisulphite Lye. A commercial concentrated solution, of specific gravity 1.32 at 60° F., containing about 45 per cent. of sodium bisulphite. This solution should be diluted to half strength and tightly corked ; it may then be relied upon to keep well. A solution equivalent to the half-strength lye may be prepared by dissolving 9½ oz. (275 gm.) of anhydrous sodium sulphite in about 25 oz. (700 c.c.) of cold water, and adding to the solution 3½ oz. by weight or about 16 fluid drams by volume (105 gm. or 56 c.c.) of sulphuric acid previously diluted to about 5 oz. (150 c.c.) and cooled. Stir continually during the addition, and finally add water to make 35 oz. (1000 c.c.)

Each ounce of this half-strength lye contains the equivalent of about 100 grains of sodium bisulphite (230 gm. per litre), and each ounce may be replaced, if more convenient, by 107 grains of potassium metabisulphite (245 gm. of this may replace 1 litre of the half-strength lye).

The lye is chiefly used for the acidification of fixing baths (1 part of half-strength lye to every ten parts of plain hypo solution) and in connection with acid amidol developers.

Sodium Borate. See Borax.

Sodium Carbonate (Fr., *Carbonate de soude ;* Ital., *Carbonato di soda ;* Ger., *Kohlensaures Natron, Natriumcarbonat,*

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Soda). $Na_2CO_3,10H_2O = 286$. Synonyms: Washing Soda, Sal Soda, Soda Crystals, Carbonate of Soda. This is prepared by several methods, which depend upon the decomposition of salt primarily. Solubility: 34 parts of crystals dissolve in 100 parts of water at 50° F., or 120 parts in 100 of boiling water, insoluble in alcohol, and 98 per cent. in glycerine. Heat has no effect upon it, except to drive off the water of crystallisation. The salt is obtainable in pure form either as the decahydrate (crystals with ten molecules of water of crystallisation) or in the anhydrous state. The two are interchangeable in the proportions of 100 parts of anhydrous salt to 286 parts of the crystals. Ordinary washing soda is liable to be very impure, and should not be used for photographic purposes. Tables giving equivalent quantities of crystalline (decahydrate) and anhydrous sodium carbonate will be found under WEIGHTS AND MEASURES. The term " monohydrated sodium carbonate," of common occurrence in American formulæ, refers to the monohydrate $Na_2CO_3.H_2O$, which is at present little used in Britain. 100 parts of this are equivalent to 85 parts of the anhydrous salt or 243 of the decahydrate.

Sodium Chloride (Fr., *Chlorure de soude, Chlorure sodique, Sel de cuisine;* Ital., *Cloruro di sodio, Sale comune;* Ger. *Chlornatrium, Natriumchlorid, Kochsalz, Edelsalz*). NaCl = 58·5. Synonyms: Common Salt, Sea Salt. This, the most abundant source of sodium, occurs native in very large deposits in Cheshire, Galicia, and Eastern Russia, also in sea water, which contains about 3 per cent. Solubility: 35 per cent. in cold, 39·6 per cent. in hot, water, insoluble in absolute, but sparingly soluble in dilute, alcohol, insoluble in ether. Ordinary salt is usually contaminated with traces of sodium sulphate and magnesium chloride, which make it hygroscopic. Salt is used for the production of cold tones on self-toning papers, as well as for precipitating silver from print washings, for making gelatino-chloride emulsions, and salting positive papers.

Sodium Hexametaphosphate. $(NaPO_3)_6 = 612$. Commercially known as Calgon. Used for softening water. When added in small amount to hard water used in the preparation of photographic developers and other solutions, it prevents the precipitation of calcium salts (as carbonate, etc.) that would otherwise occur. The quantity required is from 1 to 4 parts per thousand of water, according to the degree of hardness. Being almost exactly neutral (pH = 7·2 in dilute solution), the addition does not alter the activity of a developing solution, even if of accurately adjusted alkalinity.

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Sodium Hydrosulphite. See SODIUM HYPOSULPHITE.

Sodium Hydroxide (Fr., *Soude caustique ;* Ger., *Aetznatron*). $NaOH = 40$. Synonyms: Caustic Soda, Sodium Hydrate. Used as an accelerator in development. Occurs in white sticks or pellets, is very deliquescent, and should be kept in bottles with rubber stoppers. Is poisonous, and should not be handled too freely or it may burn the skin. See also POISONS.

Sodium Hyposulphite. $Na_2S_2O_4 2H_2O = 210$. Synonym: Sodium hydrosulphite. This is *not* "hypo," the common fixing salt used in photography, the correct chemical name of which is sodium thiosulphate (*q.v.*) The real hyposulphite is only used in photography in connection with the processing of reversal films. It is one of the most energetic reducing agents known.

Sodium hyposulphite readily picks up oxygen from the air; it must therefore be bought in sealed bottles, solutions of it must only be made up a few moments before they are required for use, and after weighing out the required amount the stock bottle must *immediately* be re-sealed or discarded.

Sodium Phosphate (Tribasic). $Na_3PO_4 12H_2O = 380$. Synonym: Trisodium Phosphate. Made by adding to phosphoric acid 50 per cent. more caustic soda than is required for neutralisation, and crystallising the solution. Twenty-two parts of the crystals dissolve in 100 parts of water at 69° F. Used as an alkali in certain developers, chiefly of fine-grain type. Developers containing it must be made up either with distilled water or with water containing sodium hexametaphosphate.

Sodium Metabisulphite. $Na_2S_2O_5 = 196$. Chiefly used in photography as an alternative to potassium metabisulphite (*q.v.*), which it may be used to replace. 7 parts of sodium metabisulphite replace 8 parts of the potassium salt. The sodium salt is more soluble, cheaper, and, as generally supplied, less pure.

Sodium Metaborate. $Na_2B_2O_4 8H_2O = 276$. See KODALK.

Sodium Sulphate (Fr., *Sulfate de soude ;* Ger., *Schwefelsaures Natron*). $Na_2SO_4, 10H_2O = 322$. Synonym: Glauber's Salt. Occurs in white powdery crystals. It is occasionally added to a developer that is to be used at a high temperature, its function being to prevent swelling of the gelatine. 30 parts of crystals dissolve in 100 parts of water at 60° F.

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Sodium Sulphide (Fr., *Sulfure de soude ;* Ger., *Natriumsulfid*). $Na_2S,9H_2O=240$. Synonym: Sulphide of Soda. Occurs in white transparent crystals, very deliquescent, and possessing an offensive odour, especially when diluted with water. Is used in the sulphide-toning process for bromide prints. It should not be kept near dry plates, printing papers, or other sensitive materials. Keeps best as a strong stock solution.

Sodium Sulphite (Fr., *Sulfite de soude ;* Ital., *Solfito di soda ;* Ger., *Schwefligsaures Natron, Natriumsulfit*). $Na_2SO_3,7H_2O=252$. Is prepared by passing sulphur dioxide through sodium carbonate in concentrated solution. Solubility of the crystals: 1 in 2½ of cold water, 1 in 1½ of hot water; insoluble in alcohol. It is used as a preservative of developers, as it absorbs oxygen, and is converted into sulphate. This salt is difficult to keep in solution as pure sulphite, but keeps better in concentrated solutions than weak ones. It has also been recommended as a fixing agent. The anhydrous sodium sulphite dissolves more readily than the crystals, and 1 part is equal to 2 parts crystals. (See DEVELOPMENT.)

A quick estimate of the purity of a sample of sulphite may be made by dissolving 5 grams of it (10 grams if crystalline) in water enough to make 100 c.c. Take 10 c.c. of this and add to it 10 c.c. of 10 per cent. sulphuric acid solution. Then run in, slowly, from a burette or small measure, a 2½ per cent. solution of potassium permanganate until the permanganate is no longer decolourized and the sulphite solution has taken on a faint permanent pink colour. The number of c.c. of permanganate needed for this indicates the purity of the sulphite; if 10 c.c. are needed, the sulphite was 100 per cent. pure; if 8 c.c., 80 per cent pure, and so on.

Sodium Thioantimoniate (Fr., *Sulphoantimoniate de soude, sel de Schlippe ;* Ger., *Schlippe'sche Salz*.) $Na_3SbS_4,9H_2O=479$. Synonyms: Schlippe's salt, sodium sulphantimoniate. This is obtained in the form of reddish-yellow crystals. Is used as a darkening agent in sulphide toning, and for intensifying negatives after mercurial bleaching. (See TONING.)

Sodium Thiosulphate. $Na_2S_2O_3,5H_2O=248$. So named because it has the constitution of a sulphate in which one atom of oxygen is replaced by sulphur (Greek Θείον sulphur); it consequently retains, slightly modified, many of the characteristics of a sulphate. Sodium sulphite to which

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air has access is slowly converted into sodium sulphate by taking on oxygen ; if sulphur is provided in place of oxygen, sodium thiosulphate is formed. Commercially, sodium thiosulphate is made by treating tank waste, or calcium sulphite. One part of crystals will dissolve in less than 2 parts of cold water ; the crystals melt at 119° F., above which temperature they are miscible with water in all proportions.

To photographers, sodium thiosulphate is universally known as " hypo," and it is used to dissolve out from a developed negative or print the sensitive silver salts that have not been used to form the actual image. This it does by converting them into a double thiosulphate of silver and sodium ($Ag_2S_2O_32Na_2S_2O_3$) which is readily soluble in water. Owing to the fact that this destroys any remaining sensitivity to light, the process is known as " fixing." It is to be noticed that the conversion is not complete unless two conditions are fulfilled ; an excess of hypo must be present, and the fixing solution must be free from dissolved silver. The implications of this are discussed under FIXING (*q.v.*).

Soft Focus. Term applied to an image the outlines of which are not completely sharp. It is generally considered that the most pleasing soft-focus effects are obtained by superposing a diffused image upon a more sharply-defined one, this giving a kind of " halo " round the lights. The effect described can be obtained by using a special lens (see SOFT FOCUS LENS), or by placing a diffusion disc (*q.v.*) over a normal lens at the time of taking the photograph.

It should be noted that the use of a diffusion disc or its equivalent (chiffon, tulle, etc.) over the lens of the enlarger is not equivalent to a soft-focus effect introduced at the time of making the negative. In the latter case, the lights tend to spread into the shadows, which is acceptable as being an effect often seen by the eye ; diffusion during enlarging, on the other hand, results in the shadows spreading into the lights.

Soft Focus Lens. A special form of large-aperture lens, designed to give an effect of the type described under SOFT FOCUS (*q.v.*). This can be achieved by any lens which suffers from spherical aberration, in which case the amount of diffusion overlaying the basic sharp image can be controlled by suitably-designed diaphragms. For portrait work, a fixed-focus telephoto lens with the separation between its components decreased from that intended by the designer is often

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very satisfactory. If general softness of outline, without the "core" of sharp definition, is required, very good results can be had from an ordinary achromatic single lens opened out to about *f*/8, or wider, according to the degree of softness required. (See LENS and DIFFUSION DISC.)

Solarisation. See REVERSAL.

Solutions and Solubility. A solution may be described, for photographic purposes, as a homogeneous liquid containing two or more distinct substances. In most cases the solvent in which the remaining substances are dissolved is water, but other solvents are also used on occasion—*e.g.*, celluloid varnish is a solution of celluloid in the organic liquid amyl acetate.

In general, the attainable strength of a solution has a natural limit set to it by the *solubility* of the dissolved substance; at ordinary room-temperature 100 parts of water will dissolve some 36 parts of common salt to give a clear solution, but if more salt is added it remains undissolved. The solution is then said to be "saturated," and the solubility of common salt is expressed by the figure 36.

It is usual to find that as the temperature of the solution is raised it will dissolve more of the substance, but the increase of solubility depends on the substance concerned. A hundred parts of water at freezing-point will dissolve 35.5 parts of common salt, while the same amount of boiling water will dissolve 39.2 parts. This increase is exceptionally small; corresponding figures for crystalline sodium sulphate (Glauber's salt) are 10.7 parts at freezing-point and 97 parts at the boiling-point of water.

The greater solubility at higher temperatures, combined with the accelerating effect on the process of solution, makes it desirable to prepare all photographic solutions with warm or hot water unless there is good reason to the contrary.

It is not possible to prepare a solution more concentrated than the normal saturated solution by boiling up water and dissolving large amounts of the solid in it, for the excess is thrown out of solution on cooling. This process is known as "crystallising out," and is used by the chemist as a means of purifying chemicals.

The photographer with a cold dark-room needs to be on his guard against this phenomenon; a saturated solution prepared in summer will deposit crystals as soon as the temperature of the dark-room falls. As the concentration of a saturated

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TABLE I.—SOLUBILITY DATA OF VARIOUS SUBSTANCES

Solubility is given as number of parts by weight of *anhydrous* substance that will dissolve in 100 parts of water.

SUBSTANCE	Solubility at 32°F. (0°C.) or maximum safe strength of stock solutions.	Solubility at 50° F. (10° C.)	Solubility at 59° F. (15° C.)	Solubility at 68° F. (20° C.)	Solubility at 77° F. (25° C.)	Solubility at 212° F. (100° C.)	REMARKS
Acetic acid	m.	m.	m.	m.	m.	m.	Glacial acid freezes at 62°F. (17°C.)
Alum (ammonia)	2·6	4·5		6·6		71	
Alum (iron)	(2·5)			7·9			
Alum (potash)	2·1	5		7·7		74·5	Ordinary alum.
Alum (chrome)	(5)				12·5		
Amidol			25			50	See separate table below.
Ammonium bichromate					40		
Ammonium bromide	(55)	66	69			127	
Ammonium carbonate	(70)		84			dec.	Is normally very impure.
Ammonium chloride	29·7	33		37		77	Sal ammoniac.
Ammonium chloropalladite	s.					v.s.	
Ammonium chloroplatinite	s.					v.s.	
Ammonium citrate	(100)		200			400	
Ammonium iodide	(150)		167			230	
Ammonium nitrate	118	150			214	871	
Ammonium oxalate	2·21			4·5			
Ammonium persulphate	58					dec.	
Ammonium thiocyanate	122			162		v.s.	Also called sulphocyanide.
Barium bromide	(80)			104		148	
Barium chloride	31·6	33		35·7		58·7	
Barium hydroxide	1·5	2·2	2·9	3·8	4·2	150	
Barium iodide	170			198		265	
Barium nitrate	5	6·9		8·6		34	
Borax	1·4	1·6			3·4	52	Sodium "biborate" $Na_2B_4O_7$.
Boric acid	1·95			4		29	
Calcium hydroxide	0·17		0·13			0·06	The solution is "lime-water."
Calcium iodide	192			203			
Citric acid	(120)				185		
Cobalt chloride	40·5					over 100	
Cobalt sulphate	24·5					v.s.	
Copper chloride	71		75			over 104	
Copper nitrate	82	95		125	150	250	
Copper sulphate	14·8		19·3		22·3	73·5	"Blue Vitriol"
Ferric chloride	75	82		91		530	"Iron perchloride"
Ferric ammonium citrate	v.s.						Solutions decompose on standing.
Ferric ammonium sulphate	(2·5)			7·9		about	
Ferrous sulphate	15·7	20·5		26·6		40	"Iron protosulphate."
Ferrous ammonium sulphate	(8)		12·8				
Gallic acid			1			33	
Glycin	s.s.					s.s.	See separate table below.
Gold chloride (auric)	(40)		68				
Hydroquinone			5·9				See separate table below.

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TABLE I. (*Continued*)

Solubility is given as number of parts by weight of *anhydrous* substance that will dissolve in 100 parts of water. SUBSTANCE	Solubility at 32° F. (0° C.) or maximum safe strength of stock solutions.	Solubility at 50° F. (10° C.)	Solubility at 59° F. (15° C.)	Solubility at 68° F. (20° C.)	Solubility at 77° F. (25° C.)	Solubility at 212° F. (100° C.)	REMARKS
Iodine	0·016	0·018	0·027	0·03	0·034	—	8·9 parts dissolve in 100 parts of 10 per cent potass. iodide at 15° C.
Kodalk	(20)			32			A proprietary alkali Figures are approximate.
Lead acetate	(30)				50	200	"Sugar of Lead."
Lead nitrate	38·8	48·3		56·5		138	
Mercuric chloride	5·7	6·6		7·3		54	"Corrosive sublimate."
Mercuric iodide	—				0·006		Soluble in various solutions of other substances.
Meritol	s.					v.s.	See separate table below.
Metol			4			25	See separate table below.
Nickel chloride	(40)	60				90	
Nickel sulphate	27·2					80	
Oxalic acid	3·6	5·3		10·2		120	Moderately poisonous.
Paraminophenol (base)	1·1					6·7	See separate table below.
Paraminophenol hydrochloride	—		10			—	See separate table below.
Paraphenylenediamine (base)	—		1			6·7	See separate table below.
Potassium bichromate	4·6	8	9	12		102	Compare *sodium* bichromate.
Potassium bromide	53	61		65		105	
Potassium carbonate	105	109		112		156	Deliquescent.
Potassium chromate	59	61		62	64	79	
Potassium citrate	v.s.						Solubility 170 at 31° C.(88°F.)
Potassium cyanide	v.s.					120	Poisonous: strong solutions corrosive.
Potassium ferricyanide	(30)	36·5	40			78	"Red prussiate."
Potassium ferrocyanide	14·5			24		74	"Yellow prussiate"
Potassium hydroxide	97	103	106	112		178	"Caustic potash." Corrosive.
Potassium iodide	128	136		144		208	
Potassium metabisulphite	(20)		30			dec.	
Potassium oxalate (neutral)	25·3						Moderately poisonous.
Potassium permanganate	2·9	4·4	5·2	6·5		v.s.	Compare *sodium* permanganate.
Potassium persulphate	1·7					—	
Potassium tartrate (neutral)	(125)		150		160	—	
Potassium tartrate (acid)	0·32	0·40		0·57		6·9	Also called bitartrate.

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TABLE I. (*Continued*)

SUBSTANCE Solubility is given as number of parts by weight of *anhydrous* substance that will dissolve in 100 parts of water.	Solubility at 32°F. (0°C.) or maximum safe strength of stock solutions.	Solubility at 50° F. (10° C.)	Solubility at 59° F. (15° C.)	Solubility at 68° F. (20° C.)	Solubility at 77° F. (25° C.)	Solubility at 212° F. (100° C.)	REMARKS
Potassium thiocyanate	177			217	239	v.s.	Also called "sulphocyanide."
Pyrocatechin	v.s.		80			v.s.	See separate table below.
Pyrogallol	44					v.s.	See separate table below.
Salicylic acid	(0·1)				0·22	—	
Silver nitrate	115	160		215		910	"Lunar caustic."
Sodium acetate	(30)	41	44	49		—	
Sodium bicarbonate	6·9	8·2		9·6		dec.	'Carbonate of soda' as used in baking.
Sodium bichromate	163	170		178		430	Compare *potassium* bichromate.
Sodium bisulphite	(40)	50				dec.	No reliable data. See SODIUM BISULPHITE LYE.
Sodium borate	1·4	1·6			3·4	52	Borax.
Sodium bromide	79			90		120	
Sodium carbonate	7·1	12·5		21	99·8	45	Washing soda is impure sodium carbonate.
Sodium chloride	35·5	35·7		35·8		39·2	Common salt.
Sodium citrate	(50)				91	220	
Sodium hydroxide	42	51·5 or more	63·5 or more	109		310	Solubility depends on hydrate present. Caustic soda; corrosive.
Sodium iodide	160	169	173			300	
Sodium nitrate	(50)		83			v.s.	
Sodium oxalate (neutral)	(2·5)		3·2		3·7	6·3	Moderately poisonous.
Sodium permanganate	v.s.					v.s.	Exact figures not available, but is many times more soluble than potassium permanganate.
Sodium phosphate (tribasic)	(8)		10·5			v.s.	
Sodium phosphate (dibasic)	2·5	3·9		9·3		100	
Sodium potassium tartrate	28	41			65		Rochelle salt.
Sodium sulphate	4·7	9	13	19	28	42	
Sodium sulphite	14	20		28·7		33	
Sodium sulphide	15·5		16·8			60	Keeps only in strong solution.
Sodium thioantimonate	s.					v.s.	Schlippe's Salt.
Sodium thiosulphate	50	60	64·5	70	76	265	Ordinary "hypo."
Tartaric acid	(100)	126		139		343	
Thiocarbamide	(8)		9			s.	Thio-urea, or Sulpho-urea.
Uranyl nitrate	100		115			v.s.	Often called "Uranium nitrate."

TABLE II.—SOLUBILITIES OF CURRENT DEVELOPING AGENTS.

This table has been compiled for the *Dictionary* by Messrs. Johnson and Sons, Ltd., of Hendon, who are actual manufacturers of the developing agents shown. The sodium sulphite and sodium carbonate solutions in which solubility is shown are of concentration approximately equal to that normally used in developing solutions.

	Water 15° C.	At 100° C.	10 per cent. Sulphite Anhyd. at 15° C.	5 per cent. Sod. Carb. Anhyd. at 15° C.	Alcohol at 15° C.	Benzene at 15° C.
Pyrogallol	Soluble 1 in 2·5 parts water. 40 in 100	Very soluble	Very soluble	Discolours badly and soluble	Soluble in 2 parts alcohol	Very slightly soluble.
Hydroquinone	Soluble in 17 parts water. 5·8 in 100	Readily soluble 20 in 100	Soluble	Soluble discolours	Freely soluble	Slightly soluble.
Pyrocatechin	Readily soluble. 80 parts soluble in 100 pts. water	Very soluble	Very soluble	Discolours badly. Very soluble	Readily soluble	Readily soluble
Paramino-phenol base	Slightly soluble 1·2 parts in 100 parts.	More soluble 6·7 in 100 approx.	Almost insoluble	Not soluble	4·5 parts in 100 soluble	Very slightly soluble
Paramino-phenol Hydrochlor.	10 parts soluble in 100 of water.	More soluble on boiling	Almost insoluble base formed	Not soluble; free base formed	Slightly soluble. 4·5 parts soluble in 100 parts	Insoluble
Metol	4 parts in 100 parts	More soluble on boiling 25 in 100	Soluble	Discolours badly Soluble	Almost insoluble	Insoluble
Glycin	Almost insoluble	Almost insoluble	Almost insoluble	Soluble in alkalies	Almost insoluble	Insoluble
Amidol	Soluble about 25 parts in 100 of water	Soluble about 50 in 100 boiling	Soluble	Discolours badly	Almost insoluble	Insoluble
Paraphenylene diamine base	Moderately soluble 1 in 100 of cold	Soluble on boiling 6·7 in 100 approx.	Slightly soluble	Soluble discolours badly	Readily soluble	Soluble
Meritol	Freely soluble	Very soluble	Soluble approx. 5 per cent.	Very soluble discolours badly	Readily soluble	Insoluble

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solution depends on temperature, it is evidently unsatisfactory to specify such a solution in a formula, as is sometimes done. In preparing a stock solution, care should be taken to allow for a possible fall in temperature, and the concentration should not exceed that corresponding to a saturated solution at the lowest temperature the dark-room is likely to reach.

Solubilities of Photographic Chemicals.

In Table I the solubility given in the first column refers to the temperature of melting ice ; any stock solution of concentration not higher than that given, may, therefore, be relied upon not to crystallise out in even the coldest weather. Figures in brackets are estimated from available solubility-data referring to slightly higher temperatures ; those not enclosed in brackets are exact. The remainder of the table is self-explanatory.

In all cases solubility is expressed as the number of parts by weight of the *anhydrous* chemical that will dissolve in 100 parts of water at the temperature named. The following abbreviations are used :—

s.s.	=	slightly soluble.
s.	=	soluble.
v.s.	=	very soluble.
m.	=	miscible.
dec.	=	decomposed.

To make this table as complete as possible, a number of sources has been consulted, and in each case the figures actually found have been used without change. This accounts for the fact that solubilities of different substances are given at different temperatures.

For questions concerning water of crystallisation, reference should be made to Equivalence, Chemical.

Conversion of the solubilities in these tables to find the corresponding weight of a hydrate can usually be avoided by reference to the article on the substance under consideration, where the solubilities of forms containing water of crystallisation are given.

Special attention is drawn to Table II of the solubilities of current developing agents.

Solutions, Making up. The photographer deciding to make up his own solutions in place of depending on ready-weighed packet chemicals will require a small pair of scales and a measure or two. Much time, temper, and unnecessary

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arithmetic will be saved if his weights are in grams and his measures marked in cubic centimetres or millilitres. A small pair of scales, sensitive to 0·1 gm. (about 1 gr.) can be obtained, complete with weights, for a few shillings. In general these scales will not accommodate more than some 10 gm. (about $\frac{1}{3}$ oz.) of a chemical at one time; it is convenient to supplement them by a simple letterscale weighing up to about 100 gm. (some 4 oz.).

As extra equipment, two or three glass beakers, or even glass jugs, are a great convenience. In buying these, remember that it is only into vessels of *thin* glass that hot water can be poured without risk of cracking. A glass funnel and a supply of cotton-wool for filtering are also often desirable, as is a stirring rod or a wide strip of fairly thick glass.

In buying chemicals some care is needed. In many cases a considerable reduction in price is obtained by buying a fair amount at one time; there will be no saving in doing so, however, if the material is used up so slowly that half has to be thrown away through deterioration on the shelf. With most substances, as ordinarily stored, maximum economy is obtained by buying about a year's supply at one time.

Sodium carbonate and sodium sulphite are much-used substances, particularly the latter; both should be bought anhydrous rather than in crystal form. The dry salt keeps better, is more easily weighed out, and dissolves practically as soon as it is put into water.

In making up a developer that is to be kept for some time the water should first be boiled gently for 3 or 4 minutes to expel dissolved air. Generally speaking, solutions should be made up, for convenience, with warm or even hot water, allowing them to cool of course before use.

It is customary to arrange the list of chemicals comprising a solution in the order in which they should be dissolved; unless the photographer has enough chemical knowledge to be sure that departures from the order given will do no harm, the chemicals should be added to the water in the prescribed order, allowing each to dissolve before adding the next. Any chemical that is in powder form should be sifted slowly into the water, stirring meanwhile. If all is shot in at once, without stirring, it may form a cake which may take a very long time to dissolve. Finally water is added to bring the solution to the prescribed total volume.

Certain developing agents have peculiarities which it is well to know. For example, metol dissolves much less readily in a

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solution of sodium sulphite than in plain water, though oxidation takes place much more rapidly in the absence of sulphite. In making up a developer containing metol it is therefore best first to dissolve a small amount—say one-tenth—of the sulphite, then dissolve the metol, and only when this is safely in solution should the rest of the sulphite be added. In the case of an M-Q developer, the hydroquinone should be added after the sulphite.

For glycin, the conditions are the exact reverse; this developing agent is practically insoluble in plain water, though it dissolves readily enough in a solution of sodium carbonate. In this case, therefore, the alkali and sulphite should be dissolved first.

It is always dangerous to try to make up a solution with less water than the formula prescribes; this may lead to a refusal to dissolve on the part of one of the constituents, or in some cases constituents already dissolved may reprecipitate on adding the next. This is particularly the case with a metol-hydroquinone developer; the two developing agents may precipitate together when the sulphite is added or, if made up with hot water, when the solution cools. If a concentrated developer is desired, one of the specially-devised formulæ (see DEVELOPMENT) should be used.

The accuracy required in making up photographic solutions is not very high by chemist's standards—except in one or two special cases an error of 3 or 4 per cent. is unimportant—but it should be remembered that it is percentage, and not absolute, error that matters. In weighing out a hundred grams, a gram extra is neither here nor there, but an extra gram of bromide in a developer calling only for a tenth of a gram might render it practically inoperative. A point to remember is that when the solution is expected to work at a definite rate—as in development by time—special care must be taken that the weights and volumes are accurately measured, and that the chemicals used are in perfect condition. Much greater laxity is permissible in a solution—say a developer for bromide paper—the action of which is controlled by observation. The same is true of a solution, such as a fixing bath or a bleacher, the work of which will in any case be taken as far as it will go.

All solutions should be stored in bottles filled well up to the necks, and securely sealed with well-fitting corks. It is worth knowing that a hard cork can be reduced to pliability by rolling it firmly on the floor beneath the sole of the shoe.

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Glass stoppers, if they really fit, are excellent for any acid, neutral, or faintly alkaline solutions; strongly alkaline solutions, including most developers containing carbonate, will cause them to stick, and a rubber cork should be used instead.

For further details on making up solutions, consult Jacobson's *All About Formulæ* (Focal Press) or the advanced textbook *Photographic Chemicals and Solutions*, by Crabtree and Matthews (Chapman and Hall).

See also SOLUTIONS AND SOLUBILITY, and WEIGHTS AND MEASURES.

Specific Gravity. The ratio of the weight of a given volume of a substance to that of an equal volume of pure water. In a solution containing only one dissolved substance, the specific gravity of the solution forms a reliable guide to the concentration of the solution. (See HYDROMETER.)

Spectacle Lens. Term applied to a true single lens consisting of a single uncemented glass. Their chief photographic use is as supplementary lenses (*q.v.*), but a spectacle lens can be used for landscape or portrait work on fairly large plates, and gives a certain amount of diffusion that is often pleasant. To obtain even definition all over the field the focal length must be long in relation to the negative; a focal length approaching double the diagonal of the negative is desirable. As a spectacle lens is not corrected for chromatic aberration, sharpest images will be obtained when photographing by some approach to monochromatic light. This is most easily done by using a non-colour-sensitive plate, in which case the lens should be brought back towards the plate by about one-fortieth of its focal length after visual focusing.

In the case of a plano-convex or meniscus lens, the image at the centre of the plate will be sharpest if the convex side faces the subject. Less good central definition, together with greater evenness of definition over the plate, will result if the convex side faces the plate. (See also LENS, SOFT FOCUS LENS, and SUPPLEMENTARY LENS.)

Spectrograph. A spectroscope (*q.v.*) so designed that an image of the spectrum is thrown on a plate in order that photographic records or measurements of spectra may be made.

Spectroscope, The. The spectroscope is chiefly used in photographic work for measuring wavelengths of light of different colours. A beam of parallel white light rays, obtained by a slit and collimating lens, is passed on to one face

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of a prism, and will emerge from the opposite face split up into the component colours of white light, or by means of a ruled grating they can be diffracted, and a spectrum so formed. The refracted or diffracted rays are collected and brought to a focus by means of a telescope revolvable about the centre of the prism table. By moving the telescope, different parts of the spectrum can be examined in turn. With a prism spectroscope the blue light is more spread out than the red, but a diffraction spectroscope gives a *normal* spectrum, the same number of Angstrom units occupying the same space at all parts of the spectrum.

Speed of Plates. See SENSITOMETRY; also EXPOSURE.

Speeds of Printing Papers. Tables showing the relative or absolute speeds of printing papers have been published from time to time, but as speeds may vary from batch to batch, and in any case can change considerably in storage, a practical check should always be made before using any published speed figure as a basis for exposure. (See also PRINTING.)

Speedgun or Speedlamp. See ELECTRONIC FLASH.

Spherical Aberration. Inability of a lens to bring rays passing through the margins of the lens to a focus at the same point as those passing through the centre. The practical result is failure to give a sharp image even in the centre of the field of view. Cutting off marginal rays by stopping down reduces spherical aberration. By comparing the positions of sharpest focus, first with the centre of the lens obscured, and then with the margins covered, the presence of spherical aberration may be detected and its extent estimated. (See LENS.)

"Spirit" Photography. Very convincing "spirit" photographs can be obtained in the following way. The general scene having been arranged, about two-thirds of the exposure is given. The lens is now capped, and, while all others are still, the "spirit" steps into its place, and the remainder of the exposure is given.

Spotlight. Type of lamp that gives a directed beam covering only a small area of the subject. Chiefly used in portraiture as a modelling light, or to illuminate the hair. The usual pattern consists of a ventilated lamphouse, containing a lamp and fitted with a simple lens of large aperture

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(usually a condenser as used in an enlarger) at or near the focus of which the lamp is placed. The whole is mounted on a stand enabling height and direction of beam to be adjusted.

Spotting Negatives. See RETOUCHING.

Spotting Prints. No print on which either black or the more common white spots can be seen should be regarded as finished. The removal of spots is simple, requiring no more than a little patience. The following notes deal with the removal of spots from bromide or gaslight prints or enlargements, but are applicable, with slight and generally obvious modifications, to prints by other processes.

Black Spots can be removed by scraping the dry print, but it is more satisfactory to bleach them away chemically. This is best done immediately the print leaves the fixing bath. Wipe the print surface dry with cotton-wool, and touch the spot with the tip of a fine sable brush that has been moistened with water and then touched on a crystal of potassium ferricyanide. As soon as bleaching takes place, wipe over with cotton-wool liberally wetted with hypo. Return the print to the hypo for a minute or two, then wash and dry as usual. If, as is usual, the ferricyanide leaves a light spot, this can be rectified when spotting the dry print.

White Spots are concealed by "spotting" the dry print with water-colour. A small tube of "Ivory Black" contains paint enough to spot many thousands of prints, and may be used, with no attempt at colour-matching, on any print of blue-black, neutral-black, or warm-black colour. Moisten a No. 0 sable brush with water, and mop it over a tiny pellet of paint on the edge of a saucer. This produces a tiny pool —just a few drops—of coloured water. The depth should be adjusted so that the colour is quite distinctly darker than the tone to which the white spot is to be brought. No attempt at matching need be made.

With the brush first dipped in the coloured water, and then freed from moisture as completely as possible by twirling it against the back of the hand, the spot is obliterated by one or two *very light* touches of the pointed tip of the brush. The smallest possible speck of colour should be applied at each touch, and if several touches are needed to fill up a spot they should be distinct. Any attempt to mop the colour on to the print is doomed to failure. Unsuccessful work can be removed by a quick wipe with a damp rag.

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Squeegee

The place of water-colour paint is often taken by water-soluble dyes, which are supplied ready-prepared, in the form of a concentrated solution, for photographic use. Matching of depth of tone is done by simple dilution, and the method of application is exactly as described for water-colour paint. Dyes have the advantage that they are absorbed by the gelatine instead of lying on the surface like paint, so making the presence of handwork much harder to detect. Unsuccessful work can be removed by soaking the print in water for a prolonged period or by bleaching the dye by the application of a solution of sodium hydrosulphite, which does not affect the image.

Squeegee. A rubber-covered roller mounted in a grip handle, or in the case of a " flat squeegee," a tongue of rubber mounted in the edge of a flat wooden handle. It is used for bringing a sheet of wet paper, or a print, into contact with a second piece of paper, a sheet of glass, or a ferrotype plate. Used chiefly in glazing prints, but is also useful for expelling surplus moisture from prints before putting them to dry. Also used in carbon and allied processes.

Stains. With modern developers, and modern methods of working, stains arising in negatives in the course of ordinary developing and fixing are rare. A scummy surface deposit, however, is fairly often met ; usually it is due either to hardness of water or to use of a very over-worked fixing bath.

Stains on prints are not uncommon ; they are due to allowing the developer to oxidise in the print before it is all washed away. If an M.Q. developer has been used, the stains are generally yellow ; with amidol they are blue to blue-brown.

Negatives and prints that have been kept for long periods often show a metallic iridescence or bronzing, turning to a brown or even yellow colour in extreme cases. This is due to the effect of sulphur compounds in the atmosphere, and is usually most marked round the edges of print or negative.

Uneven stains can quite easily arise during supplementary treatments such as toning or intensification. In every case these are due, not to the toner or intensifier, but to impurities already present in the negative or print being treated. Incomplete fixing or inadequate washing, especially the former, are the two most usual causes. For developer stains of all kinds, whether on negatives or prints, and for the iridescence of old negatives and prints mentioned above, the following treatment, due to Ilford Ltd., provides the most certain cure.

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Refix in fresh hypo, wash, and then bleach fully in :—

Potass. permanganate . .	50 gr.	(6 gm.)
Common salt	¼ oz.	(13 gm.)
Acetic acid, glacial . . .	1 oz.	(50 c.c.)
Water to	20 oz.	(1000 c.c.)

This solution oxidises almost any stain to a soluble substance. Negative or print is left in the solution, with continuous rocking of the dish, for about twice as long as is needed to bleach the image, then washed until the wash-water is no longer pink, and soaked in 5 per cent. metabisulphite solution till none of the brown colour due to the permanganate remains. It is then rinsed and redeveloped fully in a developer containing a minimum of sulphite, washed, and dried.

If a negative is *evenly* stained, it is best to make no attempt to remove the stain ; it will do no harm.

Uneven stains arising in the course of intensification or the like must be treated on the basis of what is known of their composition, and no general treatment can be suggested. In any case, many such stains have much the same composition as the image, and consequently cannot be removed at all.

Surface deposits and scum can often be removed by soaking the negative and rubbing its surface firmly, while under water in a dish, with cotton-wool. If due to hard water, the negative may be soaked in a 2 per cent. solution of hydrochloric or acetic acid, rinsed briefly, and dried. But the treatment that is most generally applicable to surface deposits, since it does not depend on the chemical nature of the deposit, is to remove it from the dry negative by friction with a slightly abrasive preparation such as Baskett's reducer (*q.v.*).

Developer stains on prints can be avoided if care is taken to wash out the developer (in water, stop-bath, or hypo) as soon as possible, and meanwhile to slow its oxidation by keeping the print in a mildly acid solution (stop-bath ; acid hypo). Desirable precautions include keeping the print under the developer during development and giving it a quick but thorough rinse before fixing to remove all developer adhering to its surface. Fixation in an acid bath is essential, and the print should be moved about freely for the first 20 seconds or so to ensure that the acid has full access to the print, and so can neutralise the alkali of the developer. Even with these precautions, stains may occur if the print is exposed to the air while in the hypo bath ; it should be turned face

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down and held under the liquid by a small weight if it tends to float. As the alkali carried over neutralises the acid in the hypo, this should be generous in amount and may be replenished if thought desirable. If these precautions are taken, stained prints need never be met with.

Small dark-brown specks on a print are generally due to chemical dust. Solutions should not be mixed in the dark-room, or in the room where prints are to be dried, if this can possibly be avoided. Particles of developing agent, particularly amidol, are likely to get carried about as invisible dust, and will cause intense stains on any print, finished or not, on which they may chance to light.

Stains on Fingers. See SKIN, EFFECTS OF CHEMICALS ON.

Stains on Negatives. See STAINS.

Stale Papers. See BROMIDE PAPER.

Stand Camera. A camera intended for use on a stand, and, except in the form of a "hand-and-stand" camera, generally incapable of use in the hand for snapshot work. (See CAMERA, also TRIPOD, SWING BACK, DISTORTION, ARCHITECTURAL PHOTOGRAPHY, and FOCUSING SCREEN.)

Stand Development. See DEVELOPMENT.

Statuettes, Photographic. A full-length photograph is mounted on thin plywood, after which the outlines of the figure are cut round with a fret-saw. The resulting "statuette" is mounted on a small wooden base suitably finished.

Stenopaic Photography (*στενωπός*, in sense of a narrow way). Synonymous with pinhole photography (*q.v.*).

Step Wedge. See WEDGE.

Stereograph or Stereogram. The term applied to the stereoscopic picture mounted and ready for viewing in the stereoscope. (See STEREOSCOPIC PHOTOGRAPHY.)

Stereoscopic Photography. The reproduction of the effects of binocular vision by photographic means. In viewing a scene, near objects can clearly be seen to stand out from more distant ones, and the distance of any object from the observer can be judged with fair accuracy. The scene, in fact, is obviously solid, not flat. This effect of solidity is

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due to the fact that the two eyes survey the scene from slightly different viewpoints, the two slightly different views being fused in the brain to give a single " solid " picture. Clearly, no photograph taken from a single viewpoint can duplicate this ; hence the " flat " appearance of a photograph.

In stereoscopic work the subject is simultaneously photographed from two viewpoints, separated (usually) by the width between the eyes ; these similar but not quite identical photographs are then mounted side by side and examined in a viewer (stereoscope) so designed that the picture taken from the right-hand viewpoint is seen by the right eye, and that taken from the left-hand viewpoint is seen by the left eye. In this way the observer is offered a close duplicate of what he would have seen in looking at the original view, and the sensation of relief, or solidity, is vividly reproduced. The wider apart are the points from which the views are taken, the more pronounced will be the stereoscopic effect ; but a distance equalling the average width between the eyes (about $2\frac{1}{2}$ to $2\frac{3}{4}$ in.) will generally be found to give the greatest truth. To this, however, there are exceptions, such as when the view is at a great distance and there are no prominent objects in the foreground (*e.g.* mountain scenery). In this case the points of separation between the two view-points for the camera may be several feet, without a markedly unnatural effect being produced. On the other hand, the nearer the subject is to the camera the greater must be the care not to have the lenses too far apart, for the relief will be exaggerated if the lenses are at too great a separation.

Claims are occasionally made for various viewers that they enable ordinary (single) photographs to be seen stereoscopically. In the strict sense, this is of course nonsense, but there is no doubt that prints or slides viewed in such an apparatus do often look more convincingly " real " than when looked at in the ordinary way. A note on the reason for this will be found under the heading of VIEWER.

Stereoscopic Cameras and Lenses.—A stereoscopic camera is in effect two identical cameras side by side, with the lenses spaced apart by the requisite distance. Those of stand-camera pattern had a wide front-panel for the two lenses, joined by a single bellows to the back, which was fitted for stereo-size plates, size $6\frac{3}{4} \times 3\frac{1}{4}$ in. To prevent the image from one lens overlapping that of the other, a removable septum or division was placed down the centre of the bellows. By removing the septum, and replacing the front panel with one carrying a

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single lens, many such cameras could be used for ordinary single-picture work. A number of half-plate cameras were also fitted with a septum, and had special carriers to allow stereo-size plates to be used in the slides.

More recent cameras have been made in box form to take plates of either 45 × 107 mm. ($1\frac{3}{4}$ × $4\frac{1}{4}$ in.) or 6 × 13 cm. ($2\frac{3}{8}$ × $5\frac{1}{8}$ in.), a third camera in some cases being placed in the centre to act as a focusing finder, so providing all the advantages of a reflex camera. A roll-film stereo reflex for pictures 6 × 13 cm. has also been made. Nearly all modern stereoscopic cameras use 35-mm. film, making a pair of pictures each 23 × 24 mm. in size, and they possess all the main features of the ordinary cine-film miniature. Most workers use reversal colour film, and viewers built to accept the pairs of transparencies, mounted in a standardized mounting frame, are readily available. Stereoscopic attachments of " beam-splitter " type (*q.v.*) are also available for several of the more elaborate single-lens miniatures.

The lenses used in a stereo camera must be of precisely the same focal length in order that the two images may be of exactly the same size. Even a small discrepancy in this direction makes it impossible for the two pictures to coalesce properly in the stereoscope.

Stereoscopic Negatives and Prints.—If a print is made direct from a stereoscopic negative, the picture taken by the right-hand lens will be on the left side of the print, and *vice versa.* That this is so can be seen by imagining the finished negative, with the print in contact with it, replaced in its original position in the camera. The right-hand picture will be on the right side, and facing the back of the camera, but will be upside down. In turning it over to get it right way up, the pictures also change sides. Such a print therefore has to be cut, and its two halves transposed. After mounting the first print with its base parallel to the bottom edge of the mount, carefully measure the distance from one object on the left of the picture, and from another on the right, to the bottom edge of the mount. The second print must be mounted so that the two images are at exactly the same heights as in the first, or they will not coalesce properly. The prints should be so trimmed that (for a standard stereoscope) the two images of a foreground object come not more than 3 in. apart when the prints are mounted. The left of the right-hand print should

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show a little more of the subject than the left of the left-hand print, and the right of the left-hand print a little more than the right of the right-hand print. A space of about $\frac{1}{16}$ to $\frac{1}{8}$ in. should be left between the prints.

To avoid the need of cutting and re-mounting a transposing frame may be used. This moves the negative bodily across the printing paper enabling the prints to be made separately, each in its correct position. Such a frame is a great convenience in printing, and is practically essential when making stereoscopic transparencies.

Using an Ordinary Camera.—An ordinary camera can be used for stereoscopic pictures of stationary objects by taking two photographs in succession, moving the camera horizontally by about 3 in. between exposures. Special tripod tops for moving the camera can be obtained. For one miniature camera an ingenious prismatic attachment is made, and this, when fitted over the lens, enables the camera to produce a stereoscopic pair of negatives, each 24 × 18 mm., in the space normally occupied by one 24 × 36 mm. frame.

Stereoscopic projection is discussed under ANAGLYPH.

(See *Stereoscopic Photography*, by A. W. Judge; also Chap. 48 of Clerc's *Photography*, which deals very fully with the subject.)

Sterry's Process. A process introduced by Mr. John Sterry for obtaining soft bromide prints from hard-contrast negatives. (See BROMIDE PAPER.)

Stilb. Unit of brightness, or luminance. A surface of luminance one stilb radiates one candela per sq. cm.

Stop-Bath. An acid bath into which plates, films or prints are placed after development to check any further developing action and to prevent stains. For this, 2 per cent. acetic acid is most commonly used, though a $2\frac{1}{2}$ per cent. solution of metabisulphite is equally effective. A hardening stop-bath (*q.v.*) is often used between development of a miniature film and fixation; this provides protection against reticulation, frilling, scratches and other possible damage.

A plain acid stop-bath, as used for papers, ceases to be effective when enough alkali has been carried over from the developer to neutralize the acid. A few drops of bromothymol blue indicator may be added; the yellow colour so imparted to the bath is invisible by the darkroom light, but

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the blue colour to which it changes when the bath loses its acidity makes the solution look very dark, and so gives warning that stained prints are likely unless the bath is replenished.

Stopping-out. See BLOCKING-OUT.

Stops. See DIAPHRAGMS.

Stress Marks. Bromide and contact-paper prints occasionally show lines, in appearance much like pencil marks, which are due to abrasion of the surface. This trouble is no longer at all prevalent, as most papers have a protective coating to prevent this. (See SUPERCOATING.) In most cases these marks can be removed by rubbing the dry print with a pledget of cotton-wool wetted with methylated spirit.

Strobo Light. Abbreviation for stroboscopic lamp, which is a type of electronic flash (*q.v.*) built to give rapidly repeating flashes at exactly equal intervals timed to synchronise with the movement of machinery or other subject in continuous motion. By this means the machinery, though in rapid motion, can be viewed or photographed as though stationary or in slow motion.

The term is quite often wrongly applied, particularly in America, to electronic flash in general.

Studio Lamp. The studio lamp most used by amateurs is a pearl lamp consuming 500 watts, having an output of about 11,000 lumens, and with an average life of 100 hours. These lamps are fitted with E.S. cap. (See also PHOTOFLOOD and OVER-RUN LAMPS.)

Subjects, Contrast Range of. See LUMINOSITY.

Sub-miniature Cameras. Cameras making negatives smaller than the normally accepted miniature size. Certainly all cameras using film narrower than 35 mm. fall into this class; 16 mm., or occasionally 9·5-mm. film, perforated or unperforated, is the negative material used. Negative size varies from 10 × 14 to 8 × 11 mm. Whether cameras for 24 × 24 or 18 × 24 mm., using 35-mm. film, will be accepted as falling into the miniature class or whether they will be called sub-miniatures is uncertain at the time of writing; usage has not as yet crystallized.

Sulphocyanide. Alternative, and less correct, term for thiocyanate, *q.v.*

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Sulphur Dioxide. (Fr., *Dioxyde de Soufre ;* Ger., *Schwefeldioxyd*). $SO_2=64$. A gas prepared by reducing sulphuric acid with charcoal, and obtainable commercially in thick glass syphons, in which it is liquefied under pressure. It has the well-known pungent smell of burning sulphur. Dissolves in water to form sulphurous acid ($H_2SO_3=82$), the acid corresponding to sulphites. A solution of sulphurous acid, or of an acid sulphite (bisulphite as $NaHSO_3$, or the commoner metabisulphite as $K_2S_2O_5$) smells distinctly of sulphur dioxide, as does an acidified solution of the odourless normal sulphite. The acid is of importance photographically as being one of the few that can be added to hypo solution to acidify it (and so prevent stains on prints or negatives) without decomposing the hypo. It is most usually added in the convenient form of metabisulphite. (See Acid Fixing Bath.) Sulphurous acid, and all sulphites and bisulphites, oxidise readily on exposure to air, forming sulphuric acid or sulphates.

See also Hypersensitizing.

Sulphuric Acid (Fr., *Acide sulfurique ;* Ger., *Schwefelsäure*). $H_2SO_4=98$. It is prepared by roasting iron or copper pyrites and oxidising the sulphur dioxide. Specific gravity, 1·845. It is used in photography as a clearing agent, and for many other purposes. It forms salts called sulphates. It is extremely corrosive and caustic. Great heat is evolved when it is mixed with water, the temperature being raised to nearly boiling point ; great care, therefore, should be used in mixing it. Always add the acid slowly to water, not water to acid.

Sulphurous Acid. See Sulphur Dioxide.

Sunk Mount. A lens is said to be in a sunk mount when the thread by means of which it is screwed into its flange lies approximately in the plane of the front combination. Practically the whole of the lens then lies behind the flange. This type of mount has been widely used in reflex cameras.

Supercoating. A layer of plain gelatine covering the emulsion (picture-forming) layer on development papers. It is added to prevent stress-marks (*q.v.*). Paper without supercoating should be used for prints to be used for the carbro or bromoil processes, as its presence makes these processes much more difficult to work.

Supplementary Lens. A lens, usually a simple spectacle lens of long focus, added to the normal camera lens to alter its focal length or to enable it to be focused, without extra

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extension, on very near objects. The focal length of the normal lens is increased by adding to it a negative (concave, diverging, or reducing) lens, and is decreased by adding to it a positive (convex, converging, or magnifying) lens.

To convert a lens of focal length f_1 to a new focal length f_2 the supplementary lens will need to have a focal length F such that $F = \frac{f_1 f_2}{f_1 - f_2}$. For example, to convert a 4-in. lens to a focal length of 3 in., the focal length of the supplementary lens will have to be $\frac{4 \times 3}{4 - 3} = \frac{12}{1} = 12$ in. To convert it to a focal length of 6 in. the supplementary lens needed will be one for which $F = \frac{4 \times 6}{4 - 6} = \frac{24}{-2} = -12$ in. The negative sign indicates that the lens, of 12-in. focal length, must be a negative (or reducing) one.

The other question, as to what new focal length f_2 will emerge when a supplementary lens of focal length F is added to a camera lens of focal length f_1, is answered by the similar formula $f_2 = \frac{f_1 F}{f_1 + F}$. Note that F must be given a negative sign if the supplementary is a concave lens. For example, to a lens of $f_1 = 6$ in., a positive supplementary F = 15 in. is to be added. The resulting focal length f_2 will be

$$\frac{6 \times 15}{6 + 15} = \frac{90}{21} = 4\tfrac{2}{7} \text{ in.}$$

If the supplementary were negative, the resulting focal length would be $\frac{6 \times (-15)}{6 - 15} = \frac{6 \times 15}{15 - 6} = \frac{90}{9} = 10$ in.

Neither of these formulæ is strictly accurate, as they do not take into consideration the separation between the lenses. As the separation has to be measured, not from the surface of the lens but from one of its nodes, and as the position of the nodes in the normal camera lens is seldom known, it would not help the photographer to complicate the formulæ by introducing a figure for the separation. (But see LENS FORMULÆ.)

When the focal length of a lens is altered, so also is the distance at which it has to be placed from the film to focus distant objects. The value of the stops is also changed, the alteration in *f*/number being exactly proportional to the alteration in focal length. When a 6-in. lens is converted to 10 in. by adding a supplementary lens, the stop marked *f*/6 becomes actually *f*/10, and all other stops are altered in the

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same ratio. New values are therefore found by multiplying the marked figures by $\frac{10}{6}$ (or $1\frac{2}{3}$), in each case.

Supplementary Lenses for Focusing.—Cameras with fixed extension frequently rely on supplementary lenses for focusing at distances below the nearest marked on the focusing mount. For focusing on a near object, the focusing mount is set at "Infinity" and a positive supplementary lens, of focal length equal to the distance of the object from the lens, is added. For focusing on slightly nearer objects the focusing mount can still be used, but calculation is necessary to determine the actual distance in focus. With a supplementary lens of focal length F, and with the scale set to the marked distance D, the distance on which focus is secured will be $\frac{DF}{D + F.}$ For the calculation both D and F must be in the same units; *e.g.*, if a 20-in. supplementary is used, and the scale is set at 5 ft. (= 60 in.), the distance of sharp focus will be $\frac{20 \times 60}{20 + 60} = \frac{20 \times 60}{80} = 15$ in.

It should be noticed that if the nearest point on which the camera can be focused is N, a series of supplementary lenses of which the focal lengths are N, $\frac{N}{2}$, $\frac{N}{3}$, $\frac{N}{4}$ ... $\frac{N}{n}$ will provide, with the aid of the focusing adjustment on the camera, means of focusing on a continuous range of distances from infinity to $\frac{N}{n + 1}$. For example, if the camera will focus to 3 feet, a suitable series of supplementary lenses would have focal lengths of 36, 18, 12, 9 and 7·2 inches. The focusing-ranges would then be respectively 36 to 18 in., 18 to 12 in., 12 to 9 in., 9 to 7·2 in., and 7·2 to 6 in.

For close-up focusing, achromatic supplementary lenses can be obtained, and with these the lens may generally be used at full aperture. If a simple spectacle lens is used (meniscus form is best) the corrections of the camera lens will be to some extent upset, and stopping down is almost certain to be necessary to give sharp definition to the corners of the picture. With this use of a supplementary lens (at fixed extension), no change in effective stop-number occurs. (See also SPECTACLE LENS.)

Swing Back. Movement fitted to many stand cameras, by the use of which the plate or film can be placed at an angle to

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the axis of the lens. Its use is twofold. When the camera is tilted upwards to include the top of a building, vertical lines do not remain parallel on the plate, but converge. At the cost of introducing some distortion, this convergence can be avoided by swinging the back of the camera into a vertical plane. (See DISTORTION, and also RISING FRONT.)

The other use of the swing-back is for focusing. If with a level camera, the back is tilted backward at the top, the part of the plate on which the image of the foreground falls is farther from the lens than that on which the image of the distance falls. With a suitable subject, this may enable both foreground and distance to be brought into focus simultaneously at a larger stop than would be possible if lens-panel and plate were rigidly parallel. For this use a swing front (see RISING FRONT) is even more suitable, as its employment does not upset the verticality of upright lines. A side-swing to either front or back is sometimes found; it has occasional value for focusing when objects on one side of the picture are nearer than on the other.

Swing Front. See under RISING FRONT.

Synchronized Shutter. Shutter fitted with electrical contacts that, by closing as the shutter operates, initiate the firing of a flash, the timing of the whole operation being such as to ensure that the flash synchronizes with the instant of exposure. See *Synchronization*, under FLASHGUN.

Synchro-Sunlight Photography. See that heading under FLASHGUN.

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T

Talbotype. See CALOTYPE.

Tank Development. See DEVELOPMENT.

Technical Camera. A type of camera fitted with many movements to enable it to be used for even the most difficult work. Usually such cameras are used on a heavy and robust stand.

Technicolor. See COLOUR PHOTOGRAPHY.

Telemeter. Another name for RANGE-FINDER, *q.v.*

Telephotography. Photography with a telephoto lens, *q.v.*

Telephoto Lens. Strictly, a lens the focal length of which is considerably in excess of its back focus. The term is often incorrectly applied to lenses of normal construction, but which have a focal length longer than is usual for the size of negative for which they are to be used.

A telephoto lens is always composed of a positive front element and a negative back element, the separation between the two being fairly large. Variation of this separation varies the focal length of the lens, but as much more elaborate corrections to the lens are needed to take advantage of this variability, and practical difficulties in handling the lens are also introduced, all modern telephoto lenses are designed in rigid mounts and give one definite focal length only. They are referred to on this account as " fixed-focus " telephoto lenses, but it is to be noted that this does *not* imply absence of a means of focusing on near objects.

The modern fixed-focus telephoto lens generally has a focal length about double (but some times three times or more) the diagonal of the negative for which it is intended, and is built to work at a distance from the film about equal to that of a

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lens of normal focal length. Such a lens can readily be made interchangeable with the normal lens on any camera having a focal-plane shutter. Its narrow angle of view necessitates a special view-finder, and extra care in avoiding camera-shake at the moment of exposure, but in all other respects it is used exactly like any normal lens. Fixed-focus telephoto lenses generally work at apertures from about $f/3{\cdot}5$ to about $f/6{\cdot}3$.

It is specially to be noticed that the value of a telephoto lens is not entirely, or even chiefly, in photographing distant objects; in practice, its main use is often for portraiture and close-up figure work, for which it enables a more distant standpoint to be used than a normal lens would permit. A particular advantage of the telephoto lens is the more natural perspective given, as compared with a lens of standard focal length. Only with extremely long-focus lenses does the angle of view become noticeably too narrow.

The older type of variable-focus telephoto lens was sometimes made up as an independent unit, but more often consisted of a "telephoto attachment" used in conjunction with the normal lens. The attachment was a corrected negative lens mounted at the back of a telescopic tube; to the front of the tube the normal lens was screwed, and the whole was then mounted on the lens panel. Such a combination is only suited for use on a stand-camera, but has the advantage that quite high magnifications can be obtained for special work. An extremely rigid camera, well supported on a stout stand, is essential for work of this type.

The magnification m given at a camera extension E when using a negative lens of focal length f_2 is given by:— $m = \frac{E}{f_2} + 1$. Thus with a camera-extension of 12 in. when using a negative lens of focal length 3 in., the magnification in use is $\frac{12}{3} + 1 = 4 + 1 = 5$ times. The effective focal length of the combination is then five times that of the positive lens, and the effective f/number, on the basis of which exposure must be calculated, is likewise five times that marked on the stop scale of the positive. If this is set at $f/4{\cdot}5$, with five times magnification exposure must be as for $f/22$.

The diagonal of the field covered on the focusing screen is given by $D = (m - 1)\frac{f_1 d_2}{f_1 - f_2}$ where f_1 is the focal length of

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the positive lens and d_2 the diameter of the *negative* lens. This formula applies when the positive is stopped down ; at larger apertures the field covered is also larger.

The following formulæ will be useful in choosing a negative lens to use with the existing camera lens (focal length f_1). For a magnification m at an extension equal to nf_1, the negative lens should have a focal length $f_2 = \frac{nf_1}{m-1}$, while to cover a negative of diagonal D it should have the diameter $d_2 = \frac{(m-n-1)}{(m-1)^2} D$. It should be set back from the positive lens by a distance $d = \frac{m-n}{m} f_1$.

Television is the reproduction of moving pictures with a wire or wireless link between transmitter and receiver. The image of the studio scene or of a cinema film is not transmitted as a whole, but is explored point by point, and signals corresponding to the illumination of each point are transmitted in a regular sequence. At the receiver the inverse process takes place in the reconstitution of the picture.

The general practice is to use a cathode-ray tube at the receiver. This consists briefly of an evacuated glass bulb with a flattened end coated with fluorescent material ; this is the screen and it fluoresces brilliantly under the impact of high-velocity electrons. An electron gun is included in the tube and produces a narrow beam of electrons which can be focused on the screen by the application of an electrostatic or electromagnetic field. The fluorescent spot on the screen can be made of the order of 0·5 to 1·0 mm. in diameter.

The beam of electrons can be deflected as required by suitable electrostatic or electromagnetic fields, so that the fluorescent spot can be moved almost instantaneously to any position on the screen. The intensity of the electron beam, and hence the brilliancy of the spot, can be controlled at will and almost instantaneously over a wide range.

The spot is arranged to move in a series of parallel lines from left to right across the screen. Referring to fig. 1, the spot starts at the top left-hand corner at A and moves steadily across the screen and slightly downwards to B. It then flies back very rapidly to a point C below A and starts to trace out a new line CD below AB. On reaching D it flies back to E and traces out EF, and so on.

At the bottom of the picture, having traced GH, it flies back

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to I and starts to trace out another line as before. In this case, however, it reaches the bottom of the picture at J before it reaches the right-hand side. The spot now flies up to K and traces out the remainder of the line KL above AB. On reaching L the spot flies back to M and then traces out MN between AB and CD. From N it goes to O and traces out OP. It continues in this way, tracing out a second series of lines in the spaces between the first series. At the bottom the lines are QR, ST, and from T the spot flies back to A and the whole process starts again.

This is the usual interlaced scanning and the complete sequence of events from A back to A forms one picture, and the

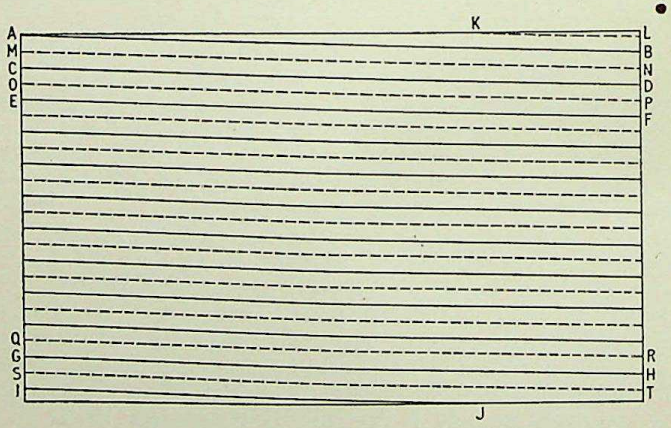

FIG. I.

half-series from A to J, or from K to A, forms one frame. In the B.B.C. transmissions there are 25 pictures a second, or 50 frames, and 405 lines to each picture.

Cathode-ray methods are used in the Emitron transmitting camera in which a beam of electrons performs precisely the same evolutions as that in the receiving tube. Synchronising pulses are inserted in the transmitted signal at the end of every line and every frame in order that the beam in the receiving tube may be kept exactly in step with that in the transmitter; at any instant, the beams must be in exactly the same positions relative to the borders of the screens.

The transmitted picture signal is at any instant proportional to the mean illumination of that small part of the image upon

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which the electron beam of the Emitron falls. The brilliance of the fluorescent spot on the screen of the receiving tube is similarly roughly proportional to the picture signal. Consequently, the brilliance of the spot is continually varying as it moves over the screen and it is these variations of brilliancy which build up the picture.

Interlaced scanning is adopted in order to reduce flicker. If the same 25 pictures a second were retained and sequential scanning were used—that is, if all lines were traced in order from top to bottom and the second set were traced out on top of the first—there would be serious flicker. By dividing the lines into two interlaced sets the flicker frequency is doubled and becomes 50 c/s. The result is no observable flicker. On close inspection of the picture, a small amount of interline flicker can be detected, but this is not noticeable at the normal viewing distance.

It must not be forgotten that at any instant there is only a single spot of light of perhaps 0·5 mm. diameter on the screen. The illusion of a picture is produced by the retentivity of the eye, helped somewhat by a small amount of persistence in the screen. In the photography of television images this must be borne in mind if good results are to be secured. As there are 25 pictures a second the ideal exposure is 1/25th of a second. With a longer exposure movement in the picture will be troublesome; in fact, longer exposures can be used only on scenes with little or no movement in them.

A shorter exposure than 1/25th of a second must not be used, because it will not give a complete picture. Exposures between 1/25th and 1/50th of a second will give a negative on which there is one frame and a fraction only of the second interlaced frame. Exposures less than 1/50th of a second will not give even one frame; part of the picture will be cut off and in what remains there will be only one-half the correct number of scanning lines.

With modern tubes the brilliancy is greater and quite good results are obtainable with a 1/25th of a second exposure provided that a $f/3{\cdot}5$ lens is used. The correct exposure from the point of view of negative density is nearer 1/12th of a second, but although somewhat under-exposed, better results are secured with about 1/25th of a second, because movement in the picture can be ignored. It is not necessary to wait until everyone in the picture is motionless.

The brilliance of the picture, however, can vary considerably as between one receiver and another, so the exposure suggested

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must be regarded as no more than a guide for a first trial.

The camera should be as far from the tube as possible, while retaining a reasonable size of image on the plate. If it is too near, the focus will deteriorate round the edges of the picture, because the end of the cathode-ray tube is convex. The curvature of the tube is made as small as possible consistent with mechanical strength, but is often appreciable.

Care should also be taken in the adjustment of the television receiver. The temptation is to increase the brilliancy too much in order to keep the exposure at a minimum. With excessive brilliancy the size of the scanning spot increases in white parts with the equivalent of a loss of focus in the television picture. Better results will be obtained at less brilliancy, but a longer exposure, or better, with a larger aperture lens.

Temperature. Since heat will always pass from a hot body to a cooler one, temperature may best be regarded as the potential, or level, of heat energy. It is measured in degrees, the measurement being conducted by observation of the expansion of a gas or liquid as temperature rises. The fundamental scale is based on the total absence of heat-energy as zero level (see ABSOLUTE TEMPERATURE), but practical thermometers take as zero either the freezing point of water (Centigrade, Réaumur) or the temperature of an arbitrary mixture of ice and salt (Fahrenheit). (See THERMOMETRY.)

As all chemical actions take place faster at higher temperatures than at low, a knowledge or control of the temperature in use is essential in all photographic operations in which time is taken into consideration. (See DEVELOPMENT and TEMPERATURE COEFFICIENT.)

Temperature Coefficient. A figure indicating the rate at which some quantity alters with varying temperature. Photographically, generally the ratio between the times taken by some chemical process at two temperatures differing by 10 Centigrade degrees. If, for example, a plate develops to a particular contrast in 5 minutes at 25° C., but takes 9 minutes to reach the same contrast in the same developer at 15° C., then the temperature coefficient of the process in 9/5 or 1·8. (See also THERMOMETRY and DEVELOPMENT.)

Temporary Support. See CARBON PROCESS.

Test Papers. Small slips of absorbent paper soaked in a solution of litmus or other dye, and used for testing any liquid for its alkalinity or acidity.

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Test Strip. Small piece of paper exposed, usually in steps, to find the correct exposure for the full-size print.

Testing Paper. See PAPERS, PHOTOGRAPHIC TESTING OF.

Textiles, Printing on. See SILK, CANVAS, DIAZOTYPE, and DYEING; also ENLARGING and CARBON PROCESS.

Texture Screen. Transparent support on which is printed a regular or irregular pattern. If this is placed against the printing paper when making an enlargement, the texture of the screen is superposed on the image.

Thermometer. Instrument for determining temperature. A bulb containing mercury or coloured alcohol is connected with a capillary tube lying on a graduated scale. The movement of the surface of the liquid along the scale, resulting from expansion or contraction of the contents of the bulb, indicates the temperature of the bulb, and hence of the environment in which the bulb is placed. For darkroom use blue-tinted alcohol (or mercury) should be chosen; the red-tinted alcohol commonly used in household thermometers is invisible in the usual darkroom light. (See TEMPERATURE and THERMOMETRY.)

Thermometry. Three scales of thermometry are in general use in different parts of the world. The Fahrenheit scale, usual in England, takes the freezing point of water as 32°, and its boiling point as 212°. In the Centigrade (or Celsius) scale usual on the Continent, these points are represented by 0° and 100° respectively, and in the Réaumur scale by 0° and 80°. The following rules for conversion therefore apply.

To convert :—

Centigrade into Fahrenheit.	Multiply by 9, divide by 5, and add 32.
Fahrenheit into Centigrade.	Subtract 32, multiply by 5, and divide by 9.
Réaumur into Centigrade.	Multiply by 5 and divide by 4.
Réaumur into Fahrenheit.	Multiply by 9, divide by 4, and add 32.
Centigrade into Réaumur.	Multiply by 4 and divide by 5.
Fahrenheit into Réaumur.	Subtract 32, multiply by 4, and divide by 9.

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TABLE I.—CONVERSION OF FAHRENHEIT, CENTIGRADE, AND RÉAUMUR

F.	C.	R	F.	C.	R.	F.	C.	R.
+212	+100	+80	170	76·67	61·33	128	53·33	42·67
211	99·44	79·56	169	76·11	60·89	127	52·78	42·22
210	98·89	79·11	168	75·55	60·44	126	52·22	41·78
209	98·33	78·67	**167**	**75**	**60**	125	51·67	41·33
208	97·78	78·22	166	74·44	59·56	124	51·11	40·89
207	97·22	77·78	165	73·89	59·11	123	50·55	40·44
206	96·67	77·33	164	73·33	58·67	**122**	**50**	**40**
205	96·11	76·89	163	72·78	58·22	121	49·44	39·56
204	95·55	76·44	162	72·22	57·78	120	48·89	39·11
203	**95**	**76**	161	71·67	57·33	119	48·33	38·67
202	94·44	75·56	160	71·11	56·89	118	47·78	38·22
201	93·89	75·11	159	70·55	56·44	117	47·22	37·78
200	93·33	74·67	**158**	**70**	**56**	116	46·67	37·33
199	92·78	74·22	157	69·44	55·56	115	46·11	36·89
198	92·22	73·78	156	68·89	55·11	114	45·55	36·44
197	91·67	73·33	155	68·33	54·67	**113**	**45**	**36**
196	91·11	72·89	154	67·78	54·22	112	44·44	35·56
195	90·55	72·44	153	67·22	53·78	111	43·89	35·11
194	**90**	**72**	152	66·67	53·33	110	43·33	34·67
193	89·44	71 56	151	66·11	52·89	109	42·78	34·22
192	88·89	71·11	150	65·55	52·44	108	42·22	33·78
191	88·33	70·67	**149**	**65**	**52**	107	41·67	33·33
190	87·78	70·22	148	64·44	51·56	106	41·11	32·89
189	87·22	69·78	147	63·89	51·11	105	40·55	32·44
188	86·67	69·33	146	63·33	50·67	**104**	**40**	**32**
187	86·11	68·89	145	62·78	50·22	103	39·44	31·56
186	85·55	68·44	144	62·22	49·78	102	38·89	31·11
185	**85**	**68**	143	61·67	49·33	101	38·33	30·67
184	84·44	67·56	142	61·11	48·89	100	37·78	30·22
183	83·89	67·11	141	60·55	48·44	99	37·22	29·78
182	83·33	66·67	**140**	**60**	**48**	98	36·67	29·33
181	82·78	66·22	139	59·44	47·56	97	36·11	28·89
180	82·22	65·78	138	58·89	47·11	96	35·55	28·44
179	81·67	65·33	137	58·33	46·67	**95**	**35**	**28**
178	81·11	64·89	136	57·78	46·22	94	34·44	27·56
177	80·55	64·44	135	57·22	45·78	93	33·89	27·11
176	**80**	**64**	134	56·67	45·33	92	33·33	26·67
175	79·44	63·56	133	56·11	44·89	91	32·78	26·22
174	78·89	63·11	132	55·55	44·44	90	32·22	25·78
173	78·33	62·67	**131**	**55**	**44**	89	31·67	25·33
172	77·78	62·22	130	54·44	43·56	88	31·11	24·89
171	77·22	61·78	129	53·89	43·11	87	30·55	24·44

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TABLE I.—CONVERSION OF FAHRENHEIT, CENTIGRADE, AND RÉAUMUR (*Continued*)

F.	C.	R.	F.	C.	R.	F.	C.	R.
86	**30**	**24**	43	6·11	4·89	1	−17·22	−13·78
85	29·44	23·56	42	5·55	4·44	0	−17·78	−14·22
84	28·89	23·11	**41**	**5**	**4**	− 1	−18·33	−14·67
83	28·33	22·67	40	4·44	3·56	− 2	−18·89	−15·11
82	27·78	22·22	39	3·89	3·11	− 3	−19·44	−15·56
81	27·22	21·78	38	3·33	2·67	− 4	**−20**	**−16**
80	26·67	21·33	37	2·78	2·22	− 5	−20·55	−16·44
79	26·11	20·89	36	2·22	1·78	− 6	−21·11	−16·89
78	25·55	20·44	35	1·67	1·33	− 7	−21·67	−17·33
77	**25**	**20**	34	1·11	0·89	− 8	−22·22	−17·78
76	24·44	19·56	33	0·55	0·40	− 9	−22·78	−18·22
75	23·89	19·11	**32**	**0**	**0**	−10	−23·33	−18·67
74	23·33	18·67	31	− 0·55	− 0·40	−11	−23·39	−19·11
73	22·78	18·22	30	− 1·11	− 0·89	−12	−24·44	−19·56
72	22·22	17·78	29	− 1·67	− 1·33	**−13**	**−25**	**−20**
71	21·67	17·33	28	− 2·22	− 1·78	−14	−25·55	−20·44
70	21·11	16·89	27	− 2·78	− 2·22	−15	−26·11	−20·89
69	20·55	16·44	26	− 3·33	− 2·67	−16	−26·67	−21·33
68	**20**	**16**	25	− 3·89	− 3·11	−17	−27·22	−21·78
67	19·44	15·56	24	− 4·44	− 3·56	−18	−27·78	−22·22
66	18·89	15·11	**23**	**− 5**	**− 4**	−19	−28·33	−22·67
65	18·33	14·67	22	− 5·55	− 4·44	−20	−28·89	−23·11
64	17·78	14·22	21	− 6·11	− 4·89	−21	−29·44	−23·56
63	17·22	13·78	20	− 6·67	− 5·33	**−22**	**−30**	**−24**
62	16·67	13·33	19	− 7·22	− 5·78	−23	−30·55	−24·44
61	16·11	12·89	18	− 7·78	− 6·22	−24	−31·11	−24·89
60	15·55	12·44	17	− 8·33	− 6·67	−25	−31·67	−25·33
59	**15**	**12**	16	− 8·89	− 7·11	−26	−32·22	−25·78
58	14·44	11·56	15	− 9·44	− 7·56	−27	−32·78	−26·22
57	13·89	11·11	**14**	**−10**	**− 8**	−28	−33·33	−26·67
56	13·33	10·67	13	−10·55	− 8·44	−29	−33·89	−27·11
55	12·78	10·22	12	−11·11	− 8·89	−30	−34·44	−27·56
54	12·22	9·78	11	−11·67	− 9·33	**−31**	**−35**	**−28**
53	11·67	9·33	10	−12·22	− 9·78	−32	−35·55	−28·44
52	11·11	8·89	9	−12·78	−10·22	−33	−36·11	−28·89
51	10·55	8·44	8	−13·33	−10·67	−34	−36·67	−29·33
50	**10**	**8**	7	−13·89	−11·11	−35	−37·22	−29·78
49	9·44	7·56	6	−14·44	−11·56	−36	−37·78	−30·22
48	8·89	7·11	**5**	**−15**	**−12**	−37	−38·33	−30·67
47	8·33	6·67	4	−15·55	−12·44	−38	−38·89	−31·11
46	7·78	6·22	3	−16·11	−12·89	−39	−39·44	−31·56
45	7·22	5·78	2	−16·67	−13·33	**−40**	**−40**	**−32**
44	6·67	5·33						

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Temperatures on the Absolute or Kelvin scale (°A or °K) can be derived from the Centigrade temperature by adding 273, and conversely temperatures quoted on the Absolute or Kelvin scale can be converted to Centigrade by subtracting 273.

(See ABSOLUTE TEMPERATURE.)

Thiocarbamide (Fr. and Ital., *Thiocarbamid ;* Ger., *Thioharnstoff, Thiocarbamid*). Synonym: Thiourea. $SC(NH_2)_2$ =76. An organic compound used in clearing solutions and sometimes as a reducer for prints. Also used in a very beautiful, but rather difficult, process of lantern-slide making (*q.v.*), and, in alkaline solution, as an odourless "darkener" in sulphide toning. (See TONING.)

Thiocyanates. A class of salts (as KCNS) formed from cyanates (as KCNO), by replacing the oxygen with sulphur. Alkaline thiocyanates find a place in gold-toning baths for printing-out papers of various kinds, and being solvents of silver bromide, have been used in some fine-grain developers. (See TONING and FINE-GRAIN DEVELOPMENT.)

Thirty-five Millimetre Camera. See MINIATURE CAMERAS.

Three-Colour Processes. See COLOUR PHOTOGRAPHY.

Time Development. See DEVELOPMENT.

Time Exposure. See SHUTTER.

Time-Gamma Curve. Graph relating, for a particular emulsion and developer, the gamma attained and the development time necessary to attain it. See SENSITOMETRY.

Timer. Term applied to dark-room clocks, especially those which can be made to give a signal, like an alarm clock, at the expiry of a pre-determined time. There are also timers, for use in making enlargements, that can be set to give an exposure of pre-determined length ; at the end of the desired time of exposure these timers automatically switch off the enlarger lamp.

Time-Lapse Photography. In cine work, making exposures at very much longer intervals than usual. The purpose is to show on the screen, in perhaps half a minute or so, an event—*e.g.*, the growth of a plant or the unfolding of a bud—that may in reality have taken many hours, days, or even weeks.

Time Scale. See INTENSITY SCALE.

Time Valve. See SHUTTER.

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Tintype. See FERROTYPE.

Titles on Prints. A useful method is to write the title first of all on the paper, before printing, with some aqueous non-actinic or opaque colour, such as gamboge or Indian ink, the same being washed off before development or toning; or the following may be used on the finished print —

Potassium iodide	10 parts
Water	30 parts
Iodine	1 part
Gum	1 part

Write with this on a dark portion of the print, when the letters will soon bleach; then fix and re-wash. Or, using a glass pen, write on glazed paper with a concentrated solution of potassium ferricyanide thickened with glycerine. Next, the paper is transferred to the moistened negative and pressed in place. When the image below the inscription is bleached by the ferricyanide, peel off the paper and transfer the negative to an ordinary hypo bath. Then wash and dry.

Tolochrome. Trade name of colour developing agent manufactured by May & Baker. (See COLOUR DEVELOPING AGENTS.)

Tone Separation. Procedure by which the normal full tonal range of a photograph is simplified until there are only a limited number of flat tones intermediate between white and black. This can be done by first making several positives, by contact or enlargement from the original negative, on "lith"-type film, which has the characteristic that once any point on it has developed up to a light grey, development at that point accelerates so that in a few seconds the image there is a solid black. Different exposures are given to the positives, so that the point on the tonal scale of the original negative beyond which the image is a full black is different in each. From each of these positives a negative, again on lith-type film, is made, exposures being such that the pale greys of the positive print full black, leaving on each negative no tone between clear film and black. The area of black on each, however, is different.

These negatives are printed in succession, and in register, on the same sheet of bromide paper, the exposure for each being timed to give the desired depth of tone in the part of

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the print corresponding to the clear part of the negative. A part of the print corresponding to full black on all negatives remains white; a part corresponding to the clear part of one negative only will be a light grey, a part corresponding to the clear part of two negatives will be darker, and so on; the total exposure should be such that where all negatives are clear the print will just develop up to a full black.

Toning. Term applied to the process of changing the colour of a photographic image. With development papers, toning is an optional process to provide a colour different from the usual black; with printing-out papers, toning was a necessary part of the production of a print.

Toning Bromide Prints.

The toning processes below have in nearly every case been worked out for use on bromide prints, but most are equally effective with prints on chlorobromide or chloride (contact) paper and with lantern slides. The colours obtained, however, are often slightly different.

Sulphide Toning (Brown and Sepia).—In this process the silver image is converted into silver sulphide. The final colour depends chiefly on the fineness of grain of the original print, and hence on details of exposure and development. An over-exposed and under-developed print will never tone to a good colour.

Bleach the fully-washed print in :—

Potassium ferricyanide . .	1 oz.	(50 gm.)
Potassium bromide .	175 gr.	(20 gm.)
Sodium carbonate (anhydr.) .	130 gr.	(15 gm.)
Water to	20 oz.	(1000 c.c.)

This solution may be kept and used repeatedly as long as it continues to bleach. Increase of bromide above the amount shown tends to produce yellowish tones.

Rinse in clean water for about 3 minutes, which will remove the yellow stain, leaving a faint buff image on a white ground. Darken in a 1 per cent. solution of sodium sulphide. This solution will not keep and must be thrown away after use. It is best to make a concentrated stock solution of sodium sulphide (about 20 per cent.), which will keep well, and dilute this as required for use.

Any trace of hypo remaining in the print will combine with

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the ferricyanide in the bleacher to give Farmer's reducer, and may reduce the lights. If the print has had perfunctory washing, replace the above bleacher by the following :—

A.	Potassium permanganate .	50 gr.	(5 gm.)
	Water to	20 oz.	(1000 c.c.)
B.	Hydrochloric acid . .	½ oz.	(25 c.c.)
	Water to	20 oz.	(1000 c.c.)

For use mix 1 part of A and 8 parts of B. More A may be added if bleaching is too slow. After washing till the wash-water is no longer pink, remove any brown stain in one or two successive baths of dilute potassium metabisulphite, wash in two or three changes of water, and darken in 1 per cent. sulphide as before. The permanganate bleacher will bleach an image that has already been sulphide toned, enabling it to be redeveloped to its original black colour if desired.

Mercury and Sulphide Toning. By varying the composition of both bleacher and darkener a wide range of tones may be had. The following process is due to H. W. Bennett. Make up the following four solutions, all of which keep well :—

A.	Potassium ferricyanide .	80 gr.	(9 gm.)
	Potassium bromide . .	120 gr.	(13·5 gm.)
	Water to	20 oz.	(1000 c.c.)
B.	Mercuric chloride . .	75 gr.	(8·5 gm.)
	Water to	20 oz.	(1000 c.c.)

C. Sodium sulphide, 20 per cent. solution.

D. Schlippe's salt, 20 per cent. solution.

The composition of bleacher and darkener required for different colours is given in Table I; the bleacher is given as parts of A and V to be mixed, while the darkener is given as number of drops of C and D to each ounce (30 c.c.) of water.

The bleachers may be kept in use as long as they work, the darkener must be used once only. After using any bleacher containing B, give prints two successive baths in 1 per cent. hydrochloric acid, followed by 10 minutes washing, before darkening. Any bleacher containing B will intensify the print to an extent depending on the amount of B it contains.

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Toning

TABLE I.—COMPOSITION OF BLEACHER AND DARKENER FOR DIFFERENT COLOURS

Colour.	*Bleacher.*	*Darkener.*
Black . . .	A1 B1	C20
Brown-black . .	A2 B1	C20
Deepest brown . .	A3 B1	C20
Deep brown . .	A6 B1	C20
Deep warm brown .	A alone	C20
Warm brown . .	A alone	C7 D14
Very warm brown .	A alone	C4 D16
Red-brown . .	A alone	C2 D18
Red chalk . .	A alone	D20

Variation in Colour may also be obtained by other means. For a rich sepia, soak the print in 1 per cent. sulphide for a few minutes; then wash, bleach, and re-sulphide. Another method is to bleach only partially; some of the original black image is then left, and any tone from a warm black to a full sepia can be had by varying the extent of bleaching. Alternatively bleaching may be complete, and the print may then be partially redeveloped in a dilute amidol developer, the darkening being completed by sulphide.

Further variation may be had by adding selenium to the darkener; a suitable stock solution is :—

Sodium sulphide . . .	4 oz.	(100 gm.)
Selenium	45 gr.	(2·5 gm.)
Water to	10 oz.	(250 c.c.)

For use, dilute with 30 parts of water. The diluted solution will not keep more than an hour or so. This gives colder tones than a plain sulphide darkener, and works well with any standard bleacher.

All these methods are particularly valuable with contact and chloro-bromide papers which, owing to their fine grain, always tend to give yellowish tones.

If a print is found, after toning, to be of too yellow a colour, it may be further toned in the direct selenium toner (below), in which it will take on a rich sepia colour.

Failures in Sulphide Toning.—A dilute solution of sulphide, if exposed to the air, is slowly converted into thiosulphate

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(hypo). Instead of darkening the bleached image, such a solution will dissolve it away. It is on this account that freshly-diluted sulphide solution is insisted upon in the above notes. A concentrated stock solution, properly corked, will keep in perfect condition for a year or more.

Blue spots, occurring only with ferricyanide bleachers, are due to specks of iron or iron rust, usually derived from the water. A filter of some simple sort over the tap will keep back any such specks of iron, and so prevent the spots.

Yellowing of the whites of the prints is very commonly seen, and is in all cases due to imperfect fixation. Prints to be toned should invariably be fixed by the "two-bath" method. (See FIXING.)

The smell of sulphide is penetrating, unpleasant, and will cause any sensitive material exposed to it to deteriorate very rapidly indeed. No unexposed paper, films, or plates should ever be left where the smell can reach them. When toning is over, the sink and the dishes used may be rinsed out with very dilute permanganate solution, which destroys any remaining sulphide and so prevents the smell from persisting.

Odourless Sulphide Toning.—Tones similar to those given by sulphide, and of equal permanence, can be obtained by using the following darkener, which is free from smell.

Thiocarbamide	44 gr.	(5 gm.)
Potassium bromide	350 gr.	(40 gm.)
Caustic soda	26 gr.	(3 gm.)
Water to	20 oz.	(1000 c.c.)

If carefully bottled, this darkener can be used repeatedly. Colder tones can be had by increasing the caustic soda. With five times the amount given, a violet tone is obtained. A warmer tone is obtained if the potassium bromide is omitted.

Selenium may be added to this darkener in the same way as to sulphide. A suitable formula is :—

Caustic soda	440 gr.	(50 gm.)
Selenium	88 gr.	(10 gm.)
Thiocarbamide	265 gr.	(30 gm.)
Water to	20 oz.	(1000 c.c.)

This is a stock solution and keeps well. For use, dilute one part with nine parts of water. The tone may again be varied

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by adding potassium bromide. Wipe the print free from any powdery deposit before drying.

Direct Toning by Hypo Alum.—A method of sulphide toning in one operation. Prepare :—

Hot water	80 oz.	(2000 c.c.)
Hypo	16 oz.	(400 gm.)
Alum	3½ oz.	(90 gm.)

Boil this mixture for several minutes when a heavy white or yellowish-white precipitate will form. This is colloidal sulphur, essential to the toning action, and no attempt should be made to filter it out. Dissolve about 6 gr. (0·25 gm.) of silver nitrate in a little water, and add ammonia till the precipitate first formed redissolves. Add this solution to the bath.

Prints are toned by immersing them in the bath, which should not be filtered, at a temperature of 100° to 120° F. (40° to 50° C.). Full toning will take about 20 to 30 minutes, according to temperature. For some papers, preliminary hardening (by soaking for 10 minutes in a saturated solution of alum) will be needed to prevent softening of the gelatine. After toning, the print should be re-fixed to remove any silver salts taken up from the bath, and then thoroughly washed. Wipe away any surface deposit with cotton-wool before drying.

The tone yielded is a purplish-sepia, slightly colder than that of normal two-bath sulphide toning. Shorter toning gives cooler tones, and anything from warm-black to the full sepia can be obtained.

The bath may be kept and used over and over again, being replenished as necessary by more of the boiled mixture of hypo and alum. The silver need only be added when the bath is first made.

Nitro-Sulphide Direct Toner. — Prepare the following solutions :—

A.	Barium sulphide . .	¼ oz.	(12·5 gm.)
	Warm water to . . .	20 oz.	(1000 c.c.)

Shake up for some time, and decant the clear solution for use. Keep tightly corked.

B. Sodium meta-nitrobenzene sulphonate, 10 per cent. solution.

For use take A 16 parts, B 1 part. If toning is too rapid, dilute this mixture with water. The final tone is not unlike

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that given by hypo-alum, and the process may be interrupted at any desired stage. Prints need not be completely freed from hypo before toning.

Liver of Sulphur Direct Toner.—The tones given by the following are similar to those given by the hypo-alum process.

Liver of sulphur . . .	15 gr.	(1·7 gm.)
Water	20 oz.	(1000 c.c.)

The bath is used at about 80° F., and tones in about 30 minutes.

Direct Toning with Selenium. This process gives sepia tones on contact papers, and brown with a purplish tinge on chloro-bromide papers. It is ineffective with bromide prints. Prepare :—

Sodium sulphite (anhydr.) .	4 oz.	(200 gm.)
Selenium	260 gr.	(30 gm.)
Water to	20 oz.	(1000 c.c.)

Dissolve the selenium in the hot sulphite solution. Keep in full bottles tightly stoppered with waxed corks. For use, add 1 part to 20 parts of 30 per cent. hypo solution. Toning takes some 20 minutes at 65° F.

Both stock and working solutions keep well, and the latter may be used until toning becomes inconveniently slow.

More rapid toning is obtained in a solution made by dissolving 2 oz. (100 gm.) of sodium sulphide in a minimum of water, dissolving in this 90 grains (10 gm.) of selenium, and diluting to 20 oz.(1000 c.c.) Any reddish stain can be removed, after toning, in a 10 per cent. solution of bisulphite or metabisulphite.

Selenium toning can be followed by ordinary sulphide toning (ferricyanide and bromide bleacher, sulphide darkener) ; the tones so obtained vary from bluish-purple to red-brown according to the time of immersion in the selenium bath.

Copper Toning.—A one-solution process giving very reasonably permanent tones from warm black through purple, plum-brown, and brown to red. The following stock solutions are required :—

A.	Copper sulphate . .	220 gr.	(25 gm.)
	Potassium citrate (neutral) .	960 gr.	(110 gm.)
	Water to	20 oz.	(1000 c.c.)
B.	Potassium ferricyanide .	175 gr.	(20 gm.)
	Potassium citrate (neutral) .	960 gr.	(110 gm.)
	Water to	20 oz.	(1000 c.c.)

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For use, mix equal parts of A and B. The stock solutions keep fairly well, but the mixed toner does not, and should be mixed only as needed. If pink stains appear in the high lights, it is an indication that the print was not completely fixed, that it was not properly washed, or that the quantity of potassium citrate is not sufficient for the particular paper in use. Immersion in 5 per cent. ammonia will usually remove any pink stain.

If a fully-toned print is a little weak, it can be strengthened by treatment, after a brief rinse, in a 5 per cent. solution of copper sulphate containing 2 to 2½ per cent. of potassium bromide, to which a little acetic acid must be added, after which the print should again be rinsed. For the most permanent results, a fully-toned print should be fixed in 5 per cent. hypo (neutral or acid) and washed thoroughly. A print toned to any colour short of a full red must not be fixed, or interaction between the red part of the image and the remaining black will result in the almost complete disappearance of both. Alternatively, the toned print may be treated with an acid amidol developer, which will both darken it and reduce the vividness of the colour by converting the residual silver salts into a black image.

Rapid Toning (about 3 minutes for red chalk) can be obtained in :—

Ammonium carbonate .	1,000 gr.	(110 gm.)
Copper sulphate . .	100 gr.	(11 gm.)
Potassium ferricyanide .	200 gr.	(22 gm.)
Water to	20 oz.	(1000 c.c.)

Dissolve in order, without the aid of heat.

Combined Copper and Sulphide Toning.—If a print fully toned by the copper process is treated with a solution containing 1 per cent. of sodium sulphide and 2 per cent. of acetic acid, a very fine permanent red-sepia tone is produced. The image is of course very considerably intensified. If copper toning is only carried far enough to give a warm black or purple-brown, the intensification on sulphiding is slight, and the resulting colour is both pleasant and permanent.

Uranium Toning.—A direct toner for shades from warm black through a pleasing range of browns to Bartolozzi red. The reputation for giving impermanent prints appears to have arisen because the final image is soluble in any alkaline solution, including ordinary tap-water. The instructions therefore require that washing after toning must be done in acidified

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water ; the acid used is one that evaporates off with the water as the print dries. Toning intensifies the image, but the intensification is trifling unless toning is carried nearly to the full red.

The toner is made up as required by mixing, in the order given, 10 per cent. stock solutions of the substances named :—

Water	15 oz.	(750 c.c.)
Uranyl nitrate . . .	1 oz.	(50 c.c.)
Rochelle salt . . .	1½ oz.	(70 c.c.)
Tartaric acid . . .	2 oz.	(100 c.c.)
Potass. ferricyanide . .	3 dr.	(20 c.c.)

Toning begins slowly, becoming more rapid as it progresses. For full red, 10 to 15 minutes is usually required. 10 oz. of the bath will tone about 360 sq. in. of prints (800 sq. cm. per 100 c.c.) When sufficiently toned, wash in several changes of water containing about 1½ dr. per pint (10 c.c. per litre) of 10 per cent. hydrochloric or acetic acid. If the whites remain tinted, clear by immersion in :—

Sodium sulphate crystals .	½ oz.	(25 gm.)
Potass. citrate, 10 per cent. sol.	1 oz.	(50 c.c.)
Water to	20 oz.	(1000 c.c.)

Rinse again in acidified water, after which the print may be dried.

For greater permanence and slightly brighter tones, the print, whether partially or completely toned, should be fixed in :—

Hypo	1 oz.	(50 gm.)
Sodium acetate . . .	90 gr.	(10 gm.)
Acetic acid, 10 per cent. .	90 min.	(10 c.c.)
Water to	20 oz.	(1000 c.c.)

After this, the print must be washed. The first wash-waters should contain 1 per cent. of boric acid, which does not decompose hypo. The last must be acidified with hydrochloric or acetic acid in the proportions already given.

If it is desired to obtain the very warm tones by a method that does not involve intensification of the print, the following process may be used. Bleach in a 3 per cent. solution of potassium ferricyanide, rendered slightly alkaline by the addition of ammonia. Wash, treat in the clearing bath above if necessary to remove yellow stain, and immerse in :—

Uranyl nitrate . . .	½ oz.	(25 gm.)
Potass. bromide . . .	45 gr.	(5 gm.)
Acetic acid (glacial) . .	90 min.	(10 c.c.)
Water to	20 oz.	(1000 c.c.)

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Toning

In this solution the print will darken to a full " uranium red " tone, but will now be a little lighter than before toning. It may be darkened, if desired, by partial redevelopment in acid amidol, or by the application of a very dilute (0·1 per cent.) solution of sodium sulphide acidified with acetic acid, after which it may be fixed and washed as already described.

The above darkening solution may be kept after use, and re-used as long as it continues to darken the prints. When exhausted, it may be given an extension of life by adding a further 35 gr. (4 gm.) of potassium bromide ; when again exhausted, it must be discarded. The quantities of potassium bromide given must on no account be exceeded.

Mixed Copper and Uranium Toning.—An exceptionally pleasing range of intermediate tones, warmer than those obtained from uranium and free from the purplish or pinkish tinge characteristic of copper, may be obtained by combining the two processes. This is most simply done by first toning in the copper bath given above (containing citrate), washing in tap-water, and then immersing the print in the darkener used in the non-intensifying two-stage uranium toning process above. In this uranium toning takes place, but the extent of toning is limited, and depends entirely upon the extent of the copper toning already done. The further toning is taken in the copper bath, the further it will go in the uranium darkener, so that the proportion of the two colours always remains constant. Further, there is no appreciable intensification or reduction, at any stage in the series of colours, when using this method of mixed toning.

If it is preferred to have the relative proportions of the two colours under the operator's control, the normal uranium toner (containing ferricyanide) may be substituted for the darkening bath mentioned above. In this, toning can be carried to a full red if desired, irrespective of the extent to which toning was carried in the copper toner. Copper toning, however, must always be done first.

After either process, the toned print may be cleared if necessary in the sodium sulphate bath, and all washing must be done in acidified water as with a uranium-toned print. Fixing is only permissible if toning in the copper bath has been taken as far as it will go.

Vanadium Toning.—This process gives green tones of good permanence. For olive-green tones the following may be used :—

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Ferric chloride	10 gr.	(1 gm.)
Ferric oxalate	10 gr.	(1 gm.)
Hydrochloric acid	50 min.	(5 c.c.)
Oxalic acid (sat-sol.)	2½ oz.	(120 c.c.)
Potassium ferricyanide	20 gr.	(2 gm.)
Vanadium chloride solution	100 min.	(10 c.c.)
Water to	20 oz.	(880 c.c.)

The vanadium chloride solution is made by adding 1 oz. (20 c.c.) of hydrochloric acid to ½ oz. (10 gm.) of the salt, which will leave a little of the salt undissolved. Immerse the print in the above, and rock until toned blue. The print is then washed in running water until the tone has changed to green and the whites are clear, and is then dried.

For an emerald-green, bleach in :—

Potassium ferricyanide	200 gr.	(22 gm.)
Ammonium carbonate	4 oz.	(200 gm.)
Water to	20 oz.	(1000 c.c.)

Wash free from stain and treat with :—

Ferric chloride	40 gr.	(4·5 gm.)
Vanadium chloride	40 gr.	(4·5 gm.)
Ammonium chloride	80 gr.	(9 gm.)
Hydrochloric acid	100 min.	(11·5 c.c.)
Water to	20 oz.	(1000 c.c.)

Wash for 10 minutes and dry.

Iron Toning.—This bath gives blue tones, and intensifies the image to a considerable extent, especially if the print is not fixed. The following toning bath (Kodak T-11) may be used. The quantities in the formula refer to the required amounts of 10 per cent. solutions of the chemicals named, except where otherwise stated :—

Water	21 oz.	(850 c.c.)
Ammonium persulphate	1 dr.	(5 c.c.)
Iron ammonium alum	3 dr.	(15 c.c.)
Oxalic acid (5 per cent.)	1½ oz.	(60 c.c.)
Potass. ferricyanide	2 dr.	(10 c.c.)
Ammonium alum	1¼ oz.	(50 c.c.)
Hydrochloric acid	2 dr.	(10 c.c.)

The bath should be of clear yellow colour.

Toning takes 2 to 10 minutes according to the colour desired ; each 10 oz. will tone some 350 sq. in. of print (700 sq. cm. per

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100 c.c.) If toning becomes slow, a further drachm (5 c.c.) of 10 per cent. hydrochloric acid may be added.

The image, of ferric ferrocyanide, is soluble in alkalies, and the print must be washed, cleared, and fixed if desired, as described above in connection with uranium toning.

Gold Toning.—A favourite method of obtaining blue or blue-black tones on chloride or chlorobromide prints; with bromide prints there is often no visible colour change, though the toner adds considerably to the permanence of the print. The Ilford IT.5 formula is:—

A.	Thiocarbamide . .	120 gr.	(14 gm.)
	Water to	20 oz.	(1000 c.c.)
B.	Citric acid (cryst.) . .	120 gr.	(14 gm.)
	Water to	20 oz.	(1000 c.c.)
C.	Gold chloride . . .	52 gr.	(6 gm.)
	Water to	20 oz.	(1000 c.c.)

For use, take 1 part each of A, B, and C and add to 10 parts water. Chlorobromide prints generally tone in 10 minutes or less; bromide prints take longer. Keep prints moving during toning, and wash well afterwards.

Applied to a print already toned by any of the sulphide methods, gold toning gives a brilliant red-chalk colour. The Ilford IT.4 toner is:—

Ammonium thiocyanate . .	175 gr.	(20 gm.)
Gold chloride . . .	9 gr.	(1 gm.)
Water to	20 oz.	(1000 c.c.)

For a full red tone, about 10 minutes is normally needed. After toning, refix in 10 per cent. hypo and wash fully.

Dye-Toning. This process is chiefly of value for transparencies, but with care it can be applied also to prints on paper. The principle involved is that of so treating the image as to yield a colourless material which will act as a " mordant " to which a dye will adhere firmly. The dye chosen must not, of course, stain plain gelatine.

A copper or uranium toner may be used for mordanting a transparency or print (fixing after toning must however, be omitted) ; the dye, of any desired colour, reinforcing the toned image to give a tone duller than that of the dye alone. Usually only a brief toning—as far as brownish black—is required. Alternatively, the following bath may be used. In this, bleaching may be complete, in which case the visible final image is

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formed almost entirely by the dye, or only partial, when the final image consists of a mixture of dye with what is left of the original image.

Copper sulphate . . .	175 gr.	(20 gm.)
Potass. citrate (neutral) .	525 gr.	(60 gm.)
Acetic acid (glacial) . .	3 dr.	(20 c.c.)
Water to	18 oz.	(900 c.c.)

When dissolved add, slowly and with constant shaking 2 oz. (100 c.c.) of a 10 per cent. solution of ammonium thiocyanate. The final solution should be quite free from turbidity, or there will be serious risk of veiling the dyed image. After bleaching the image to the desired extent, wash the transparency or print till the whites are colourless.

A transparency mordanted in this way is dyed by immersion in a bath containing a basic dye, and acidified by the addition of 2 to 10 parts per thousand of glacial acetic acid. The concentration of dye may be from 0·05 to 2 parts per thousand of bath, depending on the dye used and the depth of tint required. The time of immersion may vary from 2 to 16 minutes, according to the concentration of the bath and the effect desired. Dyeing is complete when the image has the same colour on both glass and film sides.

The dye that colours the gelatine as a whole is then washed out in successive changes of water, leaving the whites clear. If the tint of the image is too intense, it may be lightened by brief immersion in water containing a few drops of ammonia (2 parts per thousand is suitable) ; if too pale, it may be put back into the mordanting bath for further treatment and re-dyed.

For use with transparencies, any of the following dyes, or any mixture of two or more, may be used ; this list, however, by no means exhausts the possibilities. Mixed tints can be obtained, not only by mixing the dyes, but also by partial dyeing in one bath followed by rinsing and the continuation of dyeing in a second bath of different colour.

Colour	*Dye*
Warm brown	Chrysoidine
Red	*Rhodamine B
Red	*Rhodamine S
Red	Safranine
Red	Fuchsine

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Toning

Colour	*Dye*
Orange	Acridine Orange
Yellow	*Auramine
Yellow	Phosphine
Yellow	*Thioflavine
Green	Malachite Green
Blue-green	Methylene Green
Blue	Methylene Blue
Blue	*Capri Blue
Blue	Victoria Blue
Violet	Methyl Violet
Violet	Crystalline Violet

The dyes marked with an asterisk are suitable for three-colour photography.

A print mordanted in the way above described can equally well be dyed, but it is essential that the dye-solution should not come into contact with the paper base. The dye is therefore applied with a brush, the print, which for safety should have wide margins, being squeegeed, face up, to a sheet of glass to protect the back. A one per cent. solution of dye, acidified with one per cent. of glacial acetic acid, should be used, and the dye or dyes should be chosen from the following list :—

Thioflavine T
Methylene Blue
Fuchsine
Malachite Green
Methyl Violet

After dyeing, wash in running water till the slight tinting of the whites is reduced no further ; on drying, this tint generally lightens, but does not quite disappear.

For complete removal of the tint, plunge the print, after the washing mentioned, into :—

Potassium permanganate . . .	4 gm.
Sulphuric acid (10 per cent. sol.) . .	20 c.c.
Water to	1000 c.c.

Leave it in the bath for ½ to 1 minute, wash till the wash-water is no longer pink, transfer to a 2½ per cent. solution of potassium metabisulphite, rinse and dry.

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Toning P.O.P.

Silver printing-out papers must be toned before fixing if a pleasing colour is to be obtained. The process of toning consists in depositing gold or sometimes platinum on the image. The following toning baths are suitable for ordinary P.O.P.

A.	Gold chloride . . .	1½ gr.	(0·15 gm.)
	Ammonium thiocyanate .	20 gr.	(2·0 gm.)
	Water to	20 oz.	(880 c.c.)
B.	Gold chloride . . .	2 gr.	(0·2 gm.)
	Borax	120 gr.	(12 gm.)
	Water to	20 oz.	(880 c.c.)
C.	Gold chloride . . .	1 gr.	(0·1 gm.)
	Sodium phosphate . .	30 gr.	(3 gm.)
	Water to	20 oz.	(880 c.c.)
D.	Gold chloride . . .	2 gr.	(0·2 gm.)
	Sodium tungstate . .	40 gr.	(4 gm.)
	Water to	20 oz.	(880 c.c.)

A gives red to purple tones, C red and brown tones, while B and D give brown and purple tones. D tones very rapidly, with freedom from double tones. Prints should be washed in several changes of water before toning, until the wash-water is free from milkiness. Toning is best continued until but little warmth can be seen in the shadows on looking through the prints. After toning, fix in plain 10 per cent. hypo.

Albumenised Paper.—The following toner is suitable :—

Gold chloride . . .	2½ gr.	(0·25 gm.)
Sodium acetate . . .	70 gr.	(7 gm.)
Water to	20 oz.	(880 c.c.)

Wash before toning as for P.O.P., and fix in 10 per cent. hypo to which a few drops of ammonia have been added.

Platinum Toning for P.O.P.—This process gives very beautiful brown colours. First treat the prints in a 5 per cent. solution of common salt, rinse well, and tone in :—

Potassium chloroplatinite .	6 gr.	(0·6 gm.)
Citric acid	80 gr.	(8 gm.)
Water to	20 oz.	(880 c.c.)

Wash thoroughly before fixing.

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Transfer

Chocolate to black tones can be obtained by first toning in :—

Gold chloride	2 gr.	(0·2 gm.)
Sodium bicarbonate	4 gr.	(0·4 gm.)
Water to	20 oz.	(880 c.c.)

When a warm brown tone is reached, rinse and transfer to the above platinum toner.

Combined Toning and Fixing is convenient, but as prints continue to tone after all gold is exhausted, it is easy to obtain very impermanent results. Weigh out:—

Hypo	4 oz.	(200 gm.)
Alum	130 gr.	(15 gm.)
Lead nitrate (or acetate)	17½ gr.	(2 gm.)

Dissolve each separately in 6 oz. (300 c.c.) of water. Bring hypo and alum solutions separately to the boil, and mix while boiling. When cool, add the lead salt, stir, make up to 20 oz. (1000 c.c.) and allow to stand for several days, after which the white precipitate may be filtered out and discarded.

When required for use, measure out the amount of toning solution that will be needed (one ounce for each 200 sq. in. to be toned, or 100 c.c. per 40 sq. dm.) and to each 20 parts of this add 1 part of a one per cent. solution of gold chloride. Use only the quantity of bath required, and discard after use.

Selenium Toning.—This offers an economical alternative to gold or platinum toning, giving tones from brown-black to red. Prints must first be fixed and washed. Toning is rapid, and the results are permanent. The selenium is used in the form of a selenosulphate, which may conveniently be prepared thus :—

Dissolve 3 parts of powdered selenium in 100 parts of a warm 20 per cent. solution of anhydrous sodium sulphite (or 40 per cent. solution of the crystals.)

For albumenised and plain salted papers, add 2 parts of the selenosulphate solution to 1000 parts of 30 per cent. hypo, (2 c.c. per litre, or about 1 minim per ounce) while for P.O.P. or collodion paper 5 parts per thousand (5 c.c. per litre, or 2 to 3 minims per ounce) should be used. The toning bath so formed keeps well, and each 100 c.c. of bath will tone about 18 square decimetres of paper (800 sq. in. per 10 oz.).

Transfer. Term used in connection with the Carbon process (*q.v.*).

Transferotype. A printing paper made by Kodak Ltd. which is coated with a soluble gelatine before it is coated with

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silver bromide emulsion. The image can be transferred to glass, opal, wood, metal, canvas, or any other substance with a smooth surface. The print is squeegeed to the desired surface, and kept under pressure. The application of hot water causes the soluble gelatine to melt and the paper can be stripped off, leaving the picture on the new support. (See also DRY STRIPPING PAPER.)

Transparency. A positive image on a transparent support for projection or viewing by transmitted light. The term is never used for a negative.

Tray. American term for DISH (*q.v.*).

Trichrome Carbro. See COLOUR PHOTOGRAPHY.

Trick Photography. A photograph purporting to be a record of something that could not, or at least did not, exist. The subject is too wide to deal with here, but several books on it are available. (See BOOKS ON PHOTOGRAPHY. See also PHOTO-MONTAGE, POLYPOSE and "SPIRIT" PHOTOGRAPHY.)

Trimming. Except in certain kinds of professional and commercial work, prints are trimmed to a rectangular form, and the edges must be perfectly straight and clean-cut, and the corner angles true. Mechanical trimmers are mostly of the guillotine type, and they not only expedite the work, but facilitate accuracy. A print can be rapidly cut to a true rectangle of any size and proportion within the limits of the apparatus.

The amateur can, and usually does, dispense with a trimming machine, and does the work with the aid of a few accessories—a metal rule, a set-square, a suitable knife, an oil-stone, and something on which to lay the print for cutting.

For the last-named a sheet of stout glass has many advantages, although it tends to blunt the knife quickly. If wood, linoleum, millboard or other semi-soft material is used it soon gets scored, and prevents the knife cutting clean. In any case the knife needs constant sharpening on the oil-stone, and it should be of good steel so that it can take and retain a keen edge. A pen-knife with an angular point, or the knives used by mount-cutters or by shoemakers are all suitable. The metal rule should be long enough to trim the longest sides required at one cut.

It is generally advisable to trim a long side first, and this should be cut so that it is parallel with vertical or horizontal lines in the subject running in the same direction. From near the two ends of this side the width should be marked off, and

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the other long side cut. This makes the two long sides parallel. The short sides are marked off at right angles with the aid of the set square. Not only is the object of the trimming to secure a true rectangle, but also to remove all parts which are not required in the finished picture. This is particularly important when no attempt has been made to exclude such parts, by masking or otherwise, when making the print.

With single-weight papers a single cut should always be sufficient; but with double-weight it is better to give two. The knife should be run slowly and firmly in close contact with the edge of the rule, or there is a risk of its slipping and cutting the fingers.

Tripack Film. Film bearing three independent emulsions, as in all subtractive colour processes, where each emulsion is sensitized to a different colour of light.

See COLOUR PHOTOGRAPHY.

Tripod. A three-legged folding support for a camera. Most modern tripods have a small metal head bearing a tripod-screw to fit the tripod-bush on the camera, and hinged to the head are three telescopic tubular legs ending in points. The older wooden tripod has folding legs, of which the successive sections, each having a trough-shaped cross-section, are so arranged that each folds into the one above it. The bottom section generally slides into the next for fine adjustment of length, which is a point of considerable importance when working on uneven ground.

To enable the camera to be held at any angle, a ball-and-socket head is very commonly fitted to the modern metal tripod, and a useful device for larger cameras may be made by hinging two pieces of wood together, fitting a slotted side-strut and winged nut to clamp them at any required angle.

A tripod is advisable for all exposures longer than 1/50th of a sec., and for even shorter ones when a long-focus lens is in use. To avoid vibration at the moment of exposure, the shutter must be released with a flexible (wire) release whenever the camera is used on a tripod, and it is important to note that the release must on no account be drawn taut.

Trisodium Phosphate. See SODIUM PHOSPHATE (TRIBASIC).

Tropical Work. In hot damp climates special precautions of various kinds have to be taken, both in the storage and use of materials and in their processing. Dry heat is comparatively

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harmless to plates and films ; either can be supplied in hermetically sealed tins in which they will keep for prolonged periods even in the hottest climates. Once opened, deterioration is rapid. The tin should not be opened until actually needed, and once exposures have been made development should soon follow, as the latent image tends to fade away rapidly.

If developer, fixer, and wash-water can all be cooled to the same temperature, no difficulties need arise, but it is better to develop at the prevailing temperature, even if this is high, rather than to subject the film to changes in temperature from bath to bath. The following developer, containing a large dose of sodium sulphate to prevent the gelatine from swelling, can be used with most films at temperatures up to 95° F. (35° C.).

Sodium sulphite (anhydr.) .	440 gr. (50 gm.)
Paraminophenol hydrochloride	60 gr. (7 gm.)
Sodium carbonate (anhydr.) .	440 gr. (50 gm.)
Sodium sulphate (cryst.)	850 to 1750 gr. (100 to 200 gm.)
Water to	20 oz. (1000 c.c.)

The minimum quantity of sodium sulphate will suffice at temperatures up to 85° F. (30° C), but the maximum quantity will be required at a temperature of 95° F. (35° C). The development time should not exceed 4 minutes at the highest temperature, or the film may begin to reticulate ; this time, however, is well in excess of the normal development time. A little bromide may be added if there is any tendency to fog.

After development the plate or film should either be transferred direct to a hardening stop-bath, which may well be a 3 per cent. solution of chrome alum loaded with sodium sulphate in the same proportion as in the developer, or, after a brief rinse, to a freshly-mixed hardening fixer. Washing may be performed normally, but should not be too prolonged; drying should be as rapid as possible. To avoid attack during drying by bacteria or insects, the negatives may be dried with the aid of alcohol. Alternatively, some mechanical protection (*e.g.* a mosquito-net) may be provided to exclude insects; bacteria, which liquify the gelatine during drying, may be kept at bay by replacing the last washing water by a 3 per cent. solution of phenol (carbolic acid) or other suitable antiseptic.

Detailed pamphlets on tropical work are issued by the leading makers of sensitive materials.

Turn-Table. Device fitted to some stand cameras to enable them to be revolved on the tripod without shifting the latter.

Twin-Lens Reflex. See CAMERA ; also MINIATURE CAMERAS.

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Under-Exposure. The meaning of this term can best be seen by reference to the article on SENSITOMETRY. Briefly, an under-exposed negative is one in which exposure has been so short that the contrast in the darker parts of the subject is insufficient. In an extreme case, detail will actually be missing. With a short-range subject, under-exposure is best combated by prolonged development in a developer of high activity, known to develop up all developable detail. But where the brighter tones have received correct exposure, prolonged development will produce excessive contrast. An alternative, and often more satisfactory procedure, is to use the method of waterbath development (*q.v.*) or the two-bath system described under FINE-GRAIN DEVELOPMENT. In many cases, where prolonged development was required, but was not given, the use of an ultra-contrasty printing paper, or alternatively intensification of the negative, is of great assistance.

It is often noticed that a badly under-exposed negative, when held over a dark background and viewed by reflected light, will appear as a fully detailed and well-graded positive. In all such cases a greatly improved negative can be obtained by bleaching the negative in mercuric chloride (see INTENSIFICATION) and then squeegeeing to its wet surface a piece of glossy printing paper that has been exposed and developed to a full black. This gives a "positive" of quality far better than could have been attained by printing from the original negative. This positive is then copied with the camera to make a new negative.

Unsharp Masks. Slightly blurred positive transparencies, of contrast less than that of the negative from which they were made. If such a mask is bound up in contact with its negative,

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and the whole then printed from, the resulting print shows a marked apparent increase in sharpness and brilliance. The addition of the mask considerably reduces the contrast of the negative, making it necessary, for a normal print, to use printing paper of a much more contrasty grade than would be called for by the negative alone. If the mask were sharp, its effect would be precisely nullified by the more contrasty paper, but if it is slightly unsharp it reduces contrast between the major areas of the picture without reducing the contrast of the fine detail within each area. This is therefore greatly stepped up by the use of the contrasty paper, so that the final print shows vividly enhanced rendering of textures and fine detail, giving a print of startlingly brilliant quality and apparently increased sharpness.

Uranium (Fr., *Urane;* Ital., *Uranio;* Ger., *Uran*). U = 240. A rare metal never found in a pure state, but as an impure oxide, called pitchblende. It is used in the form of nitrates for preparing a printing-out paper, and for intensification and toning (*q.v.*).

Uranium Printing. The colours obtained by printing with uranium salts are decidedly pleasing, tending to a terra-cotta or copper colour, though variations are possible. Paper is sensitised by floating on a 16 per cent. solution of uranyl nitrate, or by brushing this over the surface, and is dried in the dark. The addition of 4 per cent. of either mercuric nitrate or copper sulphate to the sensitising solution has been recommended.

Paper is exposed in sunlight under a negative till all principal detail is visible, and is then developed by floating on either a 10 per cent. solution of potassium ferricyanide or a 5 per cent. solution of silver nitrate. The former gives a reddish-brown image, the latter a greyish image which can be toned, after washing, in a combined toning and fixing bath. (See TONING.) As an alternative developer, a solution of gold chloride (1 : 500) may be brushed over the image, and gives a purplish black. After development the prints should be washed in dilute hydrochloric acid (1 : 80) and then again washed thoroughly.

Uranium Toning. See TONING.

Uranyl Nitrate (Fr., *Azotate d'urane, Nitrate d'urane;* Ital., *Azotato di uranio;* Ger., *Uranylnitrat, Salpetersaures Uranoxyd*). Uranyl nitrate is prepared by digesting pitchblende in hydrochloric acid, to dissolve out the other metals,

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then roasting with charcoal twice, dissolving the residue in nitric acid, and purifying by crystallisation. It is a brilliant yellowish-green crystalline salt, very deliquescent. Solubility, 215 per cent., in cold water, 33·3 per cent. in alcohol, and 25 per cent. in ether. It is decomposed by light when in contact with organic matter into a uranous nitrate. (See TONING.)

U.S. or Uniform System. See DIAPHRAGMS.

U.V. Abbreviation for " ultra-violet." (See LIGHT.)

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V

V. Marking on shutter to indicate the setting at which the shutter will fire only some ten seconds after the release is pressed. V stands for German " Vorlauf ", or " preliminary run ". (See DELAYED ACTION.)

Vanadium Toning. See TONING.

Varnish. A solution of resinous bodies in a volatile solvent. When printing was done by contact using printing-out papers, which all contain soluble silver salts, it was very advisable to varnish all negatives to protect them from silver stains. Many formulæ for negative varnishes have been put forward in the past; those below are representative. A good " hot " varnish is :—

Best orange shellac . .	2½ oz.	(125 gm.)
Oil of lavender . . .	¼ oz.	(12·5 c.c.)
Methylated spirit . . .	20 oz.	(1000 c.c.)

To obtain a varnish that will take pencil retouching, replace the shellac with an equal quantity of sandarac. Oil of turpentine (pure) can be used in place of oil of lavender if preferred. Keep in a warm place till dissolved, then add a teaspoonful of whiting or prepared chalk, shake, set aside to clear, and decant. This varnish is flowed over the warm negative and dried by heat.

For a " cold " varnish, a 2 per cent. solution of celluloid in amyl acetate is as good as any. It may be flowed over the negative or applied with a brush.

A 10 per cent. solution of gum dammar in benzene (C_6H_6) is also suitable for films as well as plates. They can be varnished by submerging them in the varnish and then hanging them up to dry. The film must be fully dry before the varnish is applied.

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Varnish for Lantern Slides

Fixatif or Varnish for Prints.—Prints that have been worked up in black and white or are likely to receive much handling may be protected by a fine coat of varnish, similar to that applied by artists to chalk drawings: this is best done by spraying the print all over with shellac fixative, which may be bought from the artists' colourman; or make thus: In a wide-mouthed bottle put 1 part of best white shellac, and pour over it 7 parts methylated spirit. Cork it up, and leave for a day or two, giving an occasional shake up; then pour off the clear liquid, and the varnish will be suitable either for charcoal, pastel, or air-brush work. To use this, blow through a spray producer (the kind of thing used to blow perfume about). Standing well back from the photograph, blow the fine spray cloud of fixative evenly all over the print. Do not apply too much, or it may collect in patches, then run, and prove difficult to get rid of the shiny appearance when dry. By spraying thinly two or three times, the print will dry without gloss and be perfectly fixed, and safe against future injury from rubbing or contact with rough matter.

For Retouching Varnish, see RETOUCHING.

Varnish for Lantern Slides. See CRYSTAL VARNISH.

Varnish Negatives, How to. In the case of varnishes which are applied cold (see VARNISH), the liquid is simply brushed on with a broad camel's-hair brush, avoiding streakiness, or else placed in a dish containing the varnish, and then lifted out and set up to drain and dry in a warm current of air; the unnecessary varnish being easily wiped off the glass side with a piece of rag. To apply the "hot" varnishes it is necessary to first warm the negative thoroughly, first removing all dust, etc., from the film. Balance negative on the fingers and thumb of left hand and pour a pool of varnish in centre—about half the area of negative is right—and tilt negative so that varnish flows *gradually* to left-hand bottom corner. When the liquid *almost* reaches corner, tilt to flow to right-hand top corner. When this is reached, flow to left-hand top corner, and from there back to left-hand bottom corner, and from thence off by way of right-hand bottom corner into filter paper which has been arranged in a funnel in the neck of a second stock bottle of varnish. Now drain off as much varnish as possible, rocking the while. When the last drop falls, take a piece of tissue paper and run round the two lower edges, removing the varnish which collects there. When this is done, take negative by opposite corners, keeping downwards the

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corner from which varnish flowed off, and gently heat once more. Then finally put into a rack to dry hard. Varnish which may get on to the glass side of negative may be wiped off with a piece of rag soaked in spirit.

Vectograph. A stereoscopic print depending for its effectiveness on the properties of polarized light. The two prints of the stereoscopic pair are produced, in register, on the two sides of a thin sheet of transparent polarizing plastic, which is then backed with a sheet of metal. The light reflected from the two pictures is thus polarized in two directions at right angles to each other ; by viewing the composite print through spectacles composed of polarizing material, the two eye-pieces, which act as analyzers, also being set with their planes of polarization at right angles, the right eye sees the right-eye picture only, and the left eye the left-eye picture only. Full stereoscopic relief can be obtained in this way without using a stereoscope.

View Camera. Alternative name, more usual in U.S.A. than in Britain, for a stand camera (*q.v.*).

Viewer. Term applied to an apparatus allowing a print or transparency to be viewed under moderate magnification. A print may be viewed through a large lens of reading-glass type, or by reflection in a concave mirror ; for transparencies a lamp or reflector is included to provide the necessary illumination.

It is sometimes claimed for viewers that they will show ordinary photographs stereoscopically. This is, of course, impossible, as stereoscopic vision in the true sense demands that each eye shall see a slightly different picture. The effect of enhanced relief is nevertheless quite a genuine one, and can be reproduced to some extent by viewing any photograph, but particularly an enlargement, with one eye closed.

The apparent relief would appear to be due to two distinct causes. First, it must be recognised that the ordinary contact print is never seen in correct perspective ; for this, it is necessary that the print subtend at the eye an angle equal to that which the original view subtended at the lens. This can only be achieved when the distance from the eye to print is equal to the distance between lens and film in the camera—approximately, that is, to the focal length of the lens. By enlarging the print by means of a lens (or by making an enlarged print from the negative) the angle subtended by the print at the eye is increased, so giving a closer approach

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to correct perspective, and increasing the impression of reality created by the print. (See PERSPECTIVE).

The second contributory cause is closely related to true stereoscopic vision. As long as a print is seen with two eyes, it can definitely be seen that it is flat, and however convincingly true the perspective may be, the obvious and unmistakable flatness of the paper surface remains. But if one eye is closed, the fact that the print is flat is no longer in evidence, and the suggestion of the recession of planes produced by the perspective ceases to be contradicted. The eye, having no other evidence to guide it, is then able to accept the impression of depth produced by the perspective of the print, and so can accept the scene as solid. (See STEREOSCOPIC PHOTOGRAPHY).

View-Finder. An optical device built into, or attached to, a camera to indicate what part of the scene before the camera will actually be included in the photographed picture. Except where the image formed by the taking lens can be inspected on a ground-glass screen, as in a stand camera or single-lens reflex, a view-finder is a necessity for work of every kind.

For a good many years now, cameras have been used mostly at eye-level, and the " direct-vision optical " finder has for a long time been the chief type. It consists of a reversed Galilean telescope (opera-glass), built up of a negative lens on the side of the subject and a positive lens as eyepiece. This gives a brilliant reduced image of the subject, and by covering the negative lens with a mask, or cutting it to the required shape, the field of view is outlined.

This design has the disadvantage that the mask, or edge of the negative lens, is not in the same optical plane as the image of the scene, so that when the latter is seen sharply the mask is out of focus, which makes the exact limits of the field a little indefinite. In all the better grade instruments using this type of finder it is now customary to use a " bright-line " or " suspended frame " finder. The actual viewing device remains as before, except that its field of view is widened a little, and a half-silvered mirror is placed, at 45°, between the lenses. Beside the front lens of the finder is a translucent plate, behind which is an opaque graticule with clear lines cut on it. A second, fully silvered, mirror reflects these brightly illuminated lines on to the half-silvered mirror already mentioned, and so to the eye. By correctly dimensioning this simple system the bright lines are made to fall in the plane of

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the image, and so to give a very clear and precise outline to the picture area. If the camera takes interchangeable lenses, several concentric outlines, one for each lens, may be seen; in more advanced models the frames can be brought into view independently, and are sometimes selected merely by the action of changing the lens.

In the finder devised by von Albada, and known by his name, the eyepiece is of plain glass and round it is a frame to mark out the limits of the picture. The front glass is of larger size, half-silvered, and its inner surface is concave, and so curved as to produce, at infinity, a reflected image of the frame round the eyepiece. Its outer surface is parallel to the inner one, so that when looked through it is equivalent to a flat piece of glass. The net effect is that the view is seen directly, at full-size but slightly dimmed, with the frame superposed on it to mark out the limits of the view. This exact version of the Albada finder, once popular, is now out of fashion, but its principles are used in some of the modern bright-line finders by combining the frame round the eyepiece with the two-lens construction of the ordinary direct-vision finder.

A very simple finder, at one time widely used but now unpopular because of its bulk, is the simple open frame. It consists of a frame, usually of stout wire, the size of the negative and mounted over the lens. At the back of the camera a plate with a small peephole in it is mounted, over the plane of the film, to locate the eye exactly behind the centre of the frame. The view is seen direct, and objects outside the field of view are not hidden, which is valuable when photographing moving objects. If one lens is changed for another of different focal length, the finder remains accurate provided none of the lenses used is of telephoto construction. Small scaled-down versions of the frame finder have been used, but the frame then comes so near the eye as to be badly out of focus, so that accuracy suffers severely.

The brilliant finder is used at waist-level, and takes the form of a small box in the front of which is a lens of short focus. Behind it is a mirror, at an angle of 45°, which deflects the image upwards, where it is seen through a second lens, which is surrounded by a mask of suitable size and shape. The image seen is very brilliant and is upright, but reversed from right to left. In certain cameras, designed on the lines of a twin-lens reflex, the top lens of the brilliant finder is practically as big as the actual negative made by the camera, and in one model, now obsolete, a spot on the top lens was matted

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to act as a kind of coupled range-finder, view-finder and taking lens moving together for focusing.

The ground-glass finder is like a brilliant finder in construction, but the picture is seen on a tiny ground-glass screen. In this case a hood or shield is necessary if the image is to be seen in a bright light. By providing this hood, enlarging the finder, and replacing its lens by a properly-corrected anastigmat matched to the taking lens and moving with it for focusing, we arrive at the " focusing finder," or " reflex finder " of the twin-lens reflex. In a single-lens reflex, of course, taking lens and finder lens are one. (See CAMERA.)

A " universal " or " multiple " finder is used for certain miniature cameras fitted to take interchangeable lenses. As already mentioned, finders of bright-line type can be ruled with lines showing the field of view corresponding to different lenses, while in one case a tubular finder is fitted with a contracting mask, with the focal length of the lenses marked against the revolving ring by which the size of the mask is adjusted. Another finder of multiple type has a series of lenses arranged, turret-head fashion, so as to allow immediate adjustment to suit the taking lens of the camera, and in yet another pattern the magnification and the field of view are continuously adjustable by optical means, the image, seen in a frame of fixed size, growing bigger or smaller as the adjusting ring is turned. Finders of this more advanced type are elaborate optical instruments of high precision and correspondingly high price. (See also MINIATURE CAMERAS.)

Viewing Filter. See P. V. FILTER.

View-Meter. An instrument showing the view that will be included by a camera, an adjustment often being fitted so that the effect of using lenses of different focus can be studied. It usually consists of a frame that can be supported at varying known distances from the eye. In principle, it differs from a frame finder (*q.v.*, in article VIEW-FINDER) only by being designed for use apart from a camera. Frequently a blue glass or P.V. filter (*q.v.*) is fitted to allow the possibilities of the subject as a monochrome reproduction to be estimated.

Vertical Enlarger. See ENLARGING.

Vignetting. This consists of shading off the margins of a picture so that the figure or subject gradually fades away. Vignetting is most simply done when enlarging; by holding between lens and bromide paper a piece of black paper with a

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suitably-shaped hole in it, an excellent vignette is at once obtained. Vignettes in which the image shades off into black instead of white (Russian vignettes) can be similarly made, using a disc of paper instead of a mask. It is usually easiest to make a print in the normal way, and then to darken down the edges by direct light, without the interposition of the negative. (See also ENLARGING.)

Vulcanite. Another name for EBONITE (*q.v.*).

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W

Washing. Negatives and prints are washed after fixation in order to remove both the silver salts converted into soluble complexes in the fixing bath and the hypo contained in the gelatine and paper, and the permanence of the image depends very largely upon the thoroughness with which this is done. It has been estimated that an amount of hypo not exceeding 0·001 gm. in each hundred square centimetres (or 0·001 gr. per sq. in.) may be regarded as harmless to a negative.

Washing is best regarded as a process of successive dilutions. By putting a plate containing 1 gm. of hypo into 100 c.c. of water, rocking till the hypo is uniformly distributed (about 2 minutes) and pouring off all but the 5 c.c. or so adhering to and contained in the gelatine of the plate, the hypo is reduced to 1/20th its original amount. Each successive such washing similarly divides the amount of remaining hypo by twenty; four such washings will reduce it to 1/160,000th of its original amount. Provided that the plate is held under the tap for an instant on first removal from the hypo, so that only the hypo actually in the gelatine is taken to the first wash-water, four 2-minute changes, with continuous rocking, provide more than sufficient washing. For a film, which has gelatine on both sides of the support, one extra change might be advisable. Negatives can be *completely* freed from hypo by adequate washing.

Prints can be washed, singly, in the same way, but here a sixth change will be called for to allow for the extra hypo in the paper support itself; also, each immersion should last longer (say 5 minutes) to allow for the greater thickness of material from which the hypo has to diffuse out. But although this treatment will remove from prints all the hypo that is capable of being washed out, it is now known that the fibres of the paper will always retain, no matter how prolonged the washing,

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enough hypo to cause eventual fading, especially if the image is susceptible to hypo, as is the image on contact or chlorobromide paper. This retained hypo can only be removed by the use of a hypo-eliminator (*q.v.*).

In practice, proper washing is much more troublesome than the above notes would suggest, as it is seldom convenient to devote full attention to each print or film individually. Running water is usually advised for washing, but as the replacement of the water is here gradual, enormously more water is needed for effective washing. It is particularly to be noted

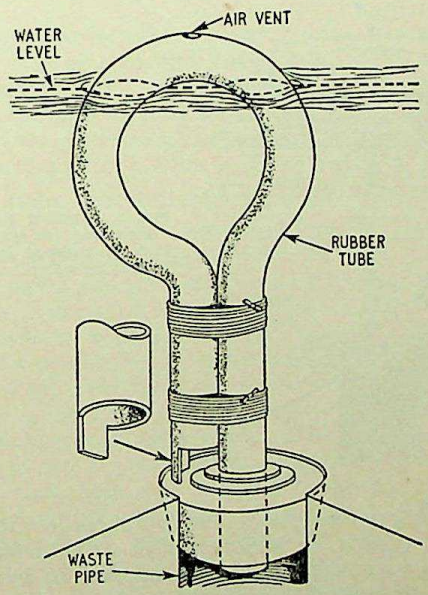

FIG 1. A simple method of maintaining the water in a sink or bath at constant level, while withdrawing water from the bottom.

that if a negative is laid at the bottom of a deep dish, and water is allowed to run slowly in at one end of the dish and overflow at the other, there may be practically no movement of the water in actual contact with the negative, and effective washing may take many hours. If, instead of a single negative, a pile of prints lies in the dish, hypo from the bottom print will have to find its way through all the others before it

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can be washed away. After being left all night in such conditions, the bottom print may well be less free from hypo than if it had been held under the tap for twenty or thirty seconds.

Proper washing entails the free access of water to the surface of a plate, or to both sides of a film or print, combined with either a continual flow of water over it or successive replacements of the water. Apart from the many individual systems used by amateurs, there are automatic washers of many types on the market, and it would be impossible here to discuss the

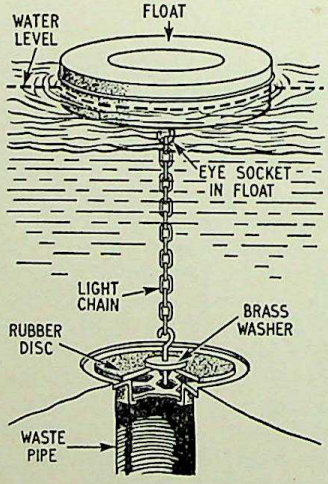

FIG. 2. Another simple method of maintaining the water in a sink or bath at constant level, while withdrawing water from the bottom.

efficiency or otherwise of each. The two sketches attached, however, suggest means by which a sink or bath may be converted into a reasonably effective washer, in which at least a certain minimum of movement of the water is ensured.

Prints may be washed in batches by leaving them in water for a short while, then removing them, placing them in a pile on a non-absorbent surface, and expelling the water from them with a roller squeegee. The vessel is emptied, rinsed, and refilled with fresh water, and the prints are returned to it *one by one*. This process is repeated every six or eight minutes; after ten or twelve such changes the prints may be regarded as reasonably well washed.

Alternatively, two dishes of water may be used, and the prints transferred, one by one, from the first to the second;

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the first is then refilled with fresh water, and the prints are transferred back to it in the same manner. Again ten or twelve changes should suffice.

The completeness with which hypo is removed by his own particular method may be checked as follows by any photographer who cares to do so.

Prepare the following solution :—

Potassium permanganate .	9 gr.	(1 gm.)
Sodium carbonate . . .	12 gr.	(1·5 gm.)
Water	20 oz.	(1000 c.c.)

Collect the drainings from several prints or negatives in a glass vessel, and in a second vessel take an equal amount of uncontaminated water. Add one drop of the above to each ; if the colour persists as long in the drainings as it does in the uncontaminated water, washing may be regarded as complete. (See also HYPO ELIMINATOR.)

Washing Soda. An impure form of sodium carbonate (*q.v.*).

Water. $H_2O = 18$. For all normal photographic purposes ordinary tap-water is sufficiently pure. Of the impurities which it is liable to contain, the most harmful is probably dissolved air, which will oxidise to some small extent any developer made up with it. The air can be effectively expelled by boiling the water gently for a few minutes, and water with which developers are to be made up should always be so treated.

Tap-water generally contains some "hardness," due to dissolved calcium and magnesium salts. Some, but not all, of the calcium can be precipitated as carbonate by boiling the water, but this does not remove magnesium salts. Any developer containing carbonate (or a caustic alkali, which is always contaminated with carbonate) will throw down a slight precipitate when made up with hard water. This precipitate (of calcium and magnesium carbonates) can readily be filtered out after the solution has stood for some time. By adding sodium hexametaphosphate or "Calgon" to the water the precipitation can be prevented altogether without alteration to the properties of the developer.

Calcium sulphate often comes out in fine crystals from a solution of a sulphite, which almost always contains a small amount of sulphate as a result of oxidation. This precipitate is again harmless if filtered out.

It should always be remembered that tap-water is usually faintly alkaline ; for certain purposes (*e.g.*, washing after

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uranium toning) this alkalinity must be removed by addition of a few drops of acid.

Waterbath Development. A method of development by which the negative is given one or more periods of immersion in still water before the process of development is completed. During these periods the developer in the shadow-portions of the negative continues to act on the emulsion until it diffuses away, but in the high lights, where much silver halide has to be reduced, it is speedily exhausted. By this means the shadows are given more development than the high lights, enabling full shadow-detail to be obtained, with full contrast, without allowing the lights to become too dense. Alternate immersions in developer and still water are usually given until development is complete. See also *B. J. Almanac*, 1932, p. 191 and 1934, p. 223.

Waterbath development is often the best way of making the best of an under-exposed plate or film, but is even more valuable in dealing with film exposed on a subject containing an excessive range of contrast. Although a normally-exposed negative developed in this way can never show theoretically correct tone-gradation, it will very often give much more satisfactory prints than one in which excessive subject-contrast has been subdued by shortened development. In the case of under-exposure, the distortion of the characteristic curve caused by waterbath development tends to compensate for the false tone-values of under-exposure.

Two-bath development (see FINEGRAIN DEVELOPMENT) is another application of the same principle.

Water-proofing Work Bench. See BLACKING.

Watkins Factor. See DEVELOPMENT.

Wedge. A piece of glass or celluloid bearing a deposit of silver, indian ink in gelatine, or other dark material the density of which is graduated from one end of the support to the other. Used in sensitometric work for giving graded exposures to sensitive material. In a *step-wedge* the gradation of density is not continuous, but there are a number of separate areas, each of which is denser than the last, but each of which individually is of even density.

Wedge Spectrogram. If in photographing the spectrum a wedge is placed over the slit of the spectroscope, with the gradation of density running parallel with the slit, the width of the spectrum at each point is determined by the sensitivity

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of the negative-material to the wavelength of the light at that point. The outline of the photographic image on the plate or film thus takes the form of a curve of sensitivity plotted against wavelength, and so indicates at a glance the colour-sensitivity. For examples of wedge spectrograms, see COLOUR-SENSITIVE EMULSIONS.

Weights and Measures. The system of weights and measures in use in Britain is extremely chaotic, and the relationships that the various units bear to one another are not by any means as simple as convenience might dictate. The photographer, especially if he be one of the many who regards unnecessary arithmetic with distaste, will do well to adopt the metric system, in which case he is never likely to be called upon for any calculation more difficult than simple multiplication or division by ten. (See METRIC SYSTEM.)

On the supposition that the metric system will be used, there follows immediately a simple conversion-rule by which any formula in English weights and measures may be read off, practically at sight, in metric units. It is only the photographer who uses the English measures who will need to read on further and wrestle with the chaotic complexities of scruples, drachms, minims, and the three different kinds of ounce.

CONVERSION OF FORMULÆ TO METRIC UNITS.

In converting a formula from one system to another it is the concentration of the solution that matters, not the total volume. There is therefore no need to convert each individual weight and volume separately, but we are free to choose any form of conversion that makes up a solution of the same composition in both systems.

A solution containing 10 grains of solid to each 20 oz. of total bulk is identical in composition with one that contains 1 gm. of solid in each 875 c.c. of total bulk. If, therefore, we have a formula in which the weights of solids are in grains, and the total volume to be made is 20 oz. (this is the usual English form), we have only to read each 10 grains as 1 gm. and put 875 c.c. in place of 20 oz. Thus :—

Metol	18 gr.	=	1·8 gm.
Sodium sulphite	500 gr.		50 gm.
Hydroquinone	60 gr.		6 gm.
Sodium carbonate	800 gr.		80 gm.
Potassium bromide	10 gr.		1 gm.
Water	20 oz.		875 c.c.

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This conversion is not approximate, it is absolutely exact. If any of the solids are given in ounces, it is sufficiently accurate to take each ounce as 440 grains. Drachms and scruples are seldom used nowadays; they are 60 and 20 grains respectively. Where a formula is given for a total volume of 10 oz., 40 oz., 80 oz., or other figure, it is, of course, necessary to multiply or divide the weights given by a suitable figure (2 or 4 in the cases given) before reading off into the metric system.

American formulæ can be treated according to the same rule (10 grains taken as 1 gm.), but in this case the total volume in the original formula will probably be either 16 oz. or 32 oz. Take as 730 c.c. or 1460 c.c. respectively. If the American formula is for 20 oz. the volume required for the conversion is 912 c.c. (*not* 875 c.c.; the U.S. fluid ounce is larger than the English one).

Conversion of Formulæ from Metric to British Measures.

A simple reversal of the above rule enables metric formulæ to be converted directly into British. Starting with a formula expressed in grams, and for a total bulk of 1000 c.c. (one litre), call each gram 10 grains, and make up to a total bulk of $22\frac{6}{7}$ oz. This conversion is absolutely exact, but it will be more convenient and quite near enough to make the total bulk 23 oz. The well-known D76 formula, for example, converts thus:—

Metol	2 gm.	20 gr.
Sodium sulphite	100 gm.	1000 gr.
Hydroquinone	5 gm.	50 gr.
Borax	2 gm.	20 gr.
Water	1000 c.c.	23 oz.

British and American Weights and Measures.

In following out the complexities of British and American systems it is easiest to start with the grain, which is the same size in both British systems and in the American system as well.

Small weights are generally given in grains nowadays, but the weights sold are generally marked in scruples and (apothecaries') drachms, which are respectively 20 and 60 grains.* The ounce of the British and American avoirdupois systems contains $437\frac{1}{2}$ grains, whereas the British apothecaries'

* The drachm of the Avoirdupois system, one-sixteenth of an Avoirdupois ounce contains $27\frac{11}{32}$ grains. Fortunately it is never used in photographic formulæ.

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ounce contains 480 grains, or 8 drachms. In a British photographic formula "1 oz." may mean either of these if no definite indication is given, but there is a strong tendency at present to prefer the avoirdupois ounce. An American ounce is always 437½ grains, and this is also the weight of "one ounce" of a chemical as bought. If the formula calls for one apothecaries' ounce of a substance (480 grains), an "ounce bottle" will, of course, not contain enough.

Fluid measure is distinctly difficult. A fluid ounce contains 437½ grains, or one avoirdupois ounce, of pure water; but for smaller volumes than this the fluid ounce is divided into 480 minims, corresponding to the division of the apothecaries' ounce into 480 grains. A minim of water thus weighs less than 1 grain, actually about 0·91 grain. A fluid drachm is one-eighth of a fluid ounce; it contains 60 minims and weighs some 54·6 grains.

The American fluid ounce is larger than the English one; an American ounce of water weighs 456 grains, or about 4 per cent. more than an English ounce. Pints, quarts, and gallons are equally troublesome: the English pint is 20 oz., the quart is 2 pints, and the gallon 4 quarts, or 160 oz. The American pint contains only 16 oz., but as these are American ounces, the American pint is equivalent to about 16⅔ English ounces, while the American quart (32 oz. American) is 33⅓ English ounces, and the American gallon (128 oz. American) is about 133⅓ oz. English. Compared with the English gallon of 160 oz., this is distinctly short measure, and it is important to know to which side of the Atlantic a formula owes its origin. As American formulæ are often copied into English books and magazines without change, it is safest in every case to take the metric version if one is given, converting it to English measures if desired by the rule set forth above.

By comparison, linear measures are easy. Both in Britain and in America the inch measures 25·4 millimetres, 12 inches go to a foot, and 3 feet make a yard. If the focusing scale of a camera is marked in metres, remember in estimating distances that the metre is "a good long yard"—not so very long, however; it measures only about 3⅜ inches, or some 9 per cent., over the 3 feet.

Percentage Solutions and Parts

Percentage Solutions.—A 10 per cent. solution is one containing 10 parts of solid in 100 parts of solution, or 100 gm.

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of solid to 1000 c.c. of solution. If the solution is to be measured out in minims, with the idea of making 10 minims contain 1 grain, then the solution should be more concentrated than 10 per cent. to allow for the fact that the fluid ounce, though weighing but 437½ grains, contains 480 minims. One ounce avoirdupois of solid should in that case be made up to a total bulk of 9·1 oz., or 9 oz. 55 minims. This, though actually an 11 per cent. solution, is often convenient for practical use, particularly for solutions of potassium bromide. When a 10 per cent. solution of this chemical is specified in a formula, an 11 per cent. solution is usually meant.

Parts.—A formula given in "parts" is to be read as expressed in the same units throughout; the actual value of the unit depends on the amount of solution required. The simplest way is to regard "parts" of a solid as grams, and "parts" of a liquid as cubic centimetres. This gives a straightforward formula in metric units, which can be converted to English measures if desired by the rule given above.

TABLES OF BRITISH AND AMERICAN WEIGHTS AND MEASURES.

British and American Weights.

1 grain (apothecaries, avoirdupois, or American) = 0·0648 gm.
1 scruple = 20 gr. = 1·296 gm
1 drachm = 60 gr. = 3·888 gm.

1 ounce avoirdupois or American	= 437½ gr. = 28·35 gm.
1 ounce apothecaries	= 480 gr. = 31·10 gm.
1 lb. avoirdupois or American	= 16 oz. (avoir.) = 453·57 gm.

American Fluid Measure.

1 minim	= $\frac{1}{480}$ oz. = 0·06161 c.c.
1 ounce	= 29·574 c.c.
1 pint	= 16 oz. = 473·18 c.c.
1 quart	= 32 oz. = 946·36 c.c.
1 gallon	= 128 oz. = 3785·43 c.c.

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British Fluid Measure.

1 minim	=	$\frac{1}{480}$ oz.
	=	0·0592 c.c.
1 drachm	=	60 minims.
	=	$\frac{1}{8}$ oz.
	=	3·5515 c.c.
1 ounce	=	480 minims.
	=	28·41 c.c.
1 pint	=	20 oz.
	=	568·245 c.c.
1 quart	=	40 oz.
	=	1136·5 c.c.
1 gallon	=	4 quarts.
	=	4546 c.c.

Linear Measure. (British or American.)

1 inch	=	25·40 mm.
1 foot	=	12 in.
	=	30·46 cm.
1 yard	=	36 in.
	=	91·39 cm.
39·37011 in.	=	100 cm.
	=	1 metre.

Square Measure. (British or American.)

1 sq. in.	=	645 sq. mm.
	=	6·45 sq. cm.
1 sq. ft.	=	144 sq. in.
	=	929 sq. cm.
	=	0·0929 sq. m.

Metric Fluid Measure.

1 c.c.	=	$\frac{1}{1000}$ litre.*
	=	16·89 minims.
	=	0·0352 oz.
1 litre	=	1000 c.c.*
	=	35·196 oz.
	=	$1\frac{3}{4}$ pints approx.

* NOTE.—Officially the millilitre, not the cubic centimetre, is the thousandth part of a litre. The difference between the two, 27 parts per million, or two drops per gallon, is only detectable in scientific work of refined precision.

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Metric Weights.

1 milligram	=	$\frac{1}{1000}$ gm.
	=	0·015432 gr.
1 centigram	=	$\frac{1}{100}$ gm.
	=	0·15432 gr.
1 decigram	=	$\frac{1}{10}$ gm.
	=	1·5432 gr.
1 gram (the unit)*	=	15·432 gr.
	=	0·03527 oz.
1 hectogram	=	100 gm.
	=	1543·2 gr.
	=	3·527 oz.
1 kilogram	=	1,000 gm.
	=	35·27 oz.
	=	2·2046 lb.

* Note that the gram is the weight of one cubic centimetre of pure water at a temperature of 4° C. This supplies the relationship between linear measure (centimetres), measures of volume (in cubic centimetres) and the unit of weight.

Tables of Metric Weights and Measures.

Metric Measures of Length.

1 mm.	=	$\frac{1}{1000}$ metre.
	=	0·0394 in.
1 cm.	=	$\frac{1}{100}$ metre.
	=	0·394 in.
1 metre (the unit)	=	39·3701 in.
	=	3·2808 ft.
	=	1·094 yd.
1 km.	=	1,000 metres.
	=	1094·2 yd.
	=	0·6214 mile.

Metric Square Measure.

1 sq. mm.	=	$\frac{1}{1,000,000}$ sq. m.
	=	0·00155 sq. in.
1 sq. cm.	=	$\frac{1}{10,000}$ sq. m.
	=	0·1552 sq. in.
1 sq. dm.	=	$\frac{1}{100}$ sq. m.
	=	15·52 sq. in.
1 sq. m (the unit).	=	1551·6 sq. in.
	=	10·775 sq. ft.

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CONVERSION TABLES.

Although the preceding tables of British, American and metric weights and measures give all the necessary multipliers and divisors for converting from any system to either of the others, or converting from one unit to another in the same system, calculation can often be avoided by making use of the tables below.

Attention is particularly drawn to Tables I to III, which make it easy to bring a formula in English or American measures into the standard form (solids all in grains, total volume 20 oz.) which is taken as a basis for the very simple method, given at the beginning of this article, for conversion into the metric system.

TABLE I.—AVOIRDUPOIS AND AMERICAN OUNCES TO GRAINS

Ounces	Grains	Ounces	Grains	Ounces	Grains
$\frac{1}{4}$	109$\frac{3}{8}$	3$\frac{3}{4}$	1640	7$\frac{1}{4}$	3172
$\frac{1}{2}$	218$\frac{3}{4}$	4	1750	7$\frac{1}{2}$	3281
$\frac{3}{4}$	328$\frac{1}{8}$	4$\frac{1}{4}$	1859	7$\frac{3}{4}$	3391
1	437$\frac{1}{2}$	4$\frac{1}{2}$	1969	8	3500
1$\frac{1}{4}$	546$\frac{7}{8}$	4$\frac{3}{4}$	2078	8$\frac{1}{2}$	3718
1$\frac{1}{2}$	656$\frac{1}{4}$	5	2187$\frac{1}{2}$	9	3937$\frac{1}{2}$
1$\frac{3}{4}$	765$\frac{5}{8}$	5$\frac{1}{4}$	2297	9$\frac{1}{2}$	4156
2	875	5$\frac{1}{2}$	2406	10	4375
2$\frac{1}{4}$	984$\frac{3}{8}$	5$\frac{3}{4}$	2516	11	4812$\frac{1}{2}$
2$\frac{1}{2}$	1094	6	2625	12	5250
2$\frac{3}{4}$	1203	6$\frac{1}{4}$	2734	13	5687$\frac{1}{2}$
3	1312$\frac{1}{2}$	6$\frac{1}{2}$	2844	14	6125
3$\frac{1}{4}$	1422	6$\frac{3}{4}$	2953	15	6562$\frac{1}{2}$
3$\frac{1}{2}$	1531	7	3062$\frac{1}{2}$	16	7000

The Avoirdupois drachm of 27$\frac{11}{32}$ grains is not used in photographic formulæ. When a drachm is mentioned it is always, both in England and America, the Apothecaries' drachm of 60 grains.

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Table II.—Scruples and Drachms to Grains

Scruple	Grains	Drachm	Grains
¼	5	¼	15
½	10	½	30
¾	15	¾	45
1	20	1	60
1½	30	2	120
2	40	3	180
3	60	4	240
4	80	5	300
5	100	6	360
6	120	7	420
		8	480

Table III.—Apothecaries Ounces to Grains

Ounces	Grains	Ounces	Grains	Ounces	Grains
¼	120	3¾	1800	7¼	3480
½	240	4	1920	7½	3600
¾	360	4¼	2040	7¾	3720
1	480	4½	2160	8	3840
1¼	600	4¾	2280	8½	4080
1½	720	5	2400	9	4320
1¾	840	5¼	2520	9½	4560
2	960	5½	2640	10	4800
2¼	1080	5¾	2760	11	5280
2½	1200	6	2880	12	5760
2¾	1320	6¼	3000	13	6240
3	1440	6½	3120	14	6720
3¼	1560	6¾	3240	15	7200
3½	1680	7	3360	16	7680

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Table IV —Grains per English Pint (20 oz.) to Grams per Litre

Grains per Pint	Grams per Litre	Grains per Pint	Grams per Litre
1	0·11404	70	7·9825
2	0·22807	80	9·1228
3	0·3421	90	10·263
4	0·4561	100	11·404
5	0·5702	150	17·106
6	0·6842	200	22·807
7	0·7982	300	34·211
8	0·9123	400	45·614
9	1·0263	500	57·018
10	1·1404	600	68·421
20	2·2807	700	79·825
30	3·4211	800	91·228
40	4·5614	900	102·63
50	5·7018	1000	114·04
60	6·8421	2000	228·07

Table V.—Ounces per English Pint to Grams per Litre

Ounces (Av.) per Pint	Grams per Litre	Ounces (Apoth) per Pint	Grams per Litre
¼	12·473	¼	13·68
½	24·945	½	27·37
¾	37·418	¾	41·05
1	49·89	1	54·73
2	99·78	2	109·46
3	149·67	3	164·19
4	199·56	4	218·92
5	249·45	5	273·65
6	299·34	6	328·38

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Table VI.—Grains per American Pint (16 oz. Amer.) to Grams per Litre

Grains per Pint	Grams per Litre	Grains per Pint	Grams per Litre
1	0·13695	70	9·5865
2	0·27390	80	10·9560
3	0·41085	90	12·3255
4	0·54780	100	13·695
5	0·68475	150	20·543
6	0·82170	200	27·390
7	0·95865	300	41·085
8	1·09560	400	54·780
9	1·23255	500	68·475
10	1·3695	600	82·170
20	2·7390	700	95·865
30	4·1085	800	109·560
40	5·4780	900	123·255
50	6·8475	1000	136·95
60	8·2170	2000	273·90

Table VII.—American Ounces per American Pint (16 oz.) to Grams per Litre

Ounces per Pint	Grams per Litre	Ounces per Pint	Grams per Litre
¼	14·98	2	119·83
½	29·96	3	179·74
¾	44·94	4	239·66
1	59·91	5	299·57
1½	89·87	6	359·48

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TABLE VIII.—GRAMS PER LITRE TO GRAINS PER ENGLISH PINT (20 OZ.)

Grams per Litre	Grains per Pint	Grams per Litre	Grains per Pint
0·1	0·88	8	70·2
0·2	1·75	9	78·9
0·3	2·63	10	87·7
0·4	3·51	20	175·4
0·5	4·38	30	263
0·6	5·26	40	351
0·7	6·14	50	438
0·8	7·02	60	526
0·9	7·89	70	614
1	8·8	80	702
2	17·5	90	789
3	26·3	100	877
4	35·1	150	1315
5	43·8	200	1754
6	52·6	300	2631
7	61·4	400	3508

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Table IX.—Grams per Litre to Ounces and Grains per Pint

Grams per Litre	Av. oz. and gr. per pint		Apoth. oz. and gr. per. pint	
	Oz.	Gr.	Oz.	Gr.
50	1	0	—	438
55	1	44	1	2
60	1	89	1	46
65	1	133	1	90
70	1	176	1	134
75	1	220	1	177
80	1	264	1	221
85	1	309	1	265
90	1	352	1	309
95	1	396	1	353
100	2	2	1	398
110	2	90	2	4
120	2	177	2	92
125	2	221	2	136
130	2	265	2	179
140	2	353	2	267
150	3	3	2	355
160	3	91	2	442
170	3	178	3	51
175	3	222	3	95
180	3	266	3	139
190	3	354	3	226
200	4	4	3	314
210	4	92	3	402
220	4	179	4	9
225	4	223	4	53
230	4	267	4	97
240	4	355	4	184
250	5	5	4	272
260	5	93	4	360
270	5	180	4	447
275	5	224	5	12
280	5	268	5	56
290	5	356	5	143
300	6	6	5	231
310	6	94	5	319
320	6	181	5	406
325	6	225	5	450
330	6	269	6	14
340	6	357	6	102
350	7	7	6	189
375	7	226	6	409
400	8	8	7	148

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Table X.—Grains Per American Pint (16 oz.) To Grains Per English Pint

Grains per American pint	Grains per English pint	Grains per American pint	Grains per English pint
1·0	1·2	150	180
1·5	1·8	200	240
2·0	2·4	250	300
3·0	3·6	300	360
4·0	4·8	350	420
5·0	6·0	400	480
6·0	7·2	450	540
7·0	8·4	500	600
8·0	9·6	600	720
9·0	10·8	700	839
10·0	12·0	800	959
15·0	18·0	900	1079
20·0	24·0	1000	1199
25·0	30·0	1500	1799
30·0	36·0	2000	2399
35·0	42·0	2500	2998
40·0	48·0	3000	3598
45·0	54·0	3500	4198
50·0	60·0	4000	4798
60·0	72·0	4500	5397
70·0	84·0	5000	5996
80·0	96·0	6000	7196
90·0	108·0	7000	8395
100·0	120·0	8000	9594

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TABLE XI.—OUNCES PER AMERICAN PINT (16 OZ.) TO OUNCES (AV. AND APOTH.) PER ENGLISH PINT

Oz. per American pint	Oz. (Av.) and grains per English pint		Oz. (Apoth.) and grains per English pint	
	Oz.	Gr.	Oz.	Gr.
¼	0	131	0	131
½	0	263	0	263
¾	0	394	0	394
1	1	88	1	45
1¼	1	219	1	176
1½	1	350	1	308
1¾	2	43	1	438
2	2	174	2	89
2¼	2	305	2	220
2½	2	436	2	352
2¾	3	130	3	3
3	3	262	3	134
3¼	3	393	3	265
3½	4	86	3	396
3¾	4	218	4	48
4	4	349	4	179
4½	5	174	4	441
5	5	436	5	223
5½	6	261	6	6
6	7	86	6	268
6½	7	348	7	50
7	8	173	7	313
7½	8	435	8	95
8	9	260	8	358

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Table XII.—Inches to Centimetres

Inches	Centimetres	Inches	Centimetres
1	2·54	13	33·02
2	5·08	14	35·56
3	7·62	15	38·10
4	10·16	16	40·64
5	12·70	17	43·18
6	15·24	18	45·72
7	17·78	19	48·26
8	20·32	20	50·80
9	22·86	25	63·50
10	25·40	30	76·20
11	27·94	36	91·44
12	30·48	39·37	100

Table XIII.—Fractions of Inches to Millimetres

In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.
1/64	0·397	17/64	6·75	33/64	13·10	49/64	19·45
1/32	0·794	9/32	7·14	17/32	13·49	25/32	19·84
3/64	1·19	19/64	7·54	35/64	13·89	51/64	20·24
1/16	1·59	5/16	7·94	9/16	14·29	13/16	20·64
5/64	1·98	21/64	8·33	37/64	14·68	53/64	21·03
3/32	2·38	11/32	8·73	19/32	15·08	27/32	21·43
7/64	2·78	23/64	9·13	39/64	15·48	55/64	21·83
1/8	3·18	3/8	9·525	5/8	15·875	7/8	22·225
9/64	3·57	25/64	9·92	41/64	16·27	57/64	22·62
5/32	3·97	13/32	10·32	21/32	16·67	29/32	23·02
11/64	4·37	27/64	10·72	43/64	17·07	59/64	23·42
3/16	4·76	7/16	11·11	11/16	17·46	15/16	23·81
13/64	5·16	29/64	11·51	45/64	17·86	61/64	24·21
7/32	5·56	15/32	11·91	23/32	18·26	31/32	24·61
15/64	5·95	31/64	12·30	47/64	18·65	63/64	25·00
1/4	6·35	1/2	12·70	3/4	19·05	1	25·40

One sixty-fourth of an inch is equal to 0·396875 mm.

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Table XIV.—Centimetres to Inches

Centimetres	Inches	Centimetres	Inches
1	0·39	15	5·91
2	0·79	20	7·87
3	1·18	30	11·81
4	1·57	40	15·75
5	1·97	50	19·69
6	2·36	60	23·62
7	2·76	70	27·56
8	3·15	80	31·50
9	3·54	90	35·43
10	3·94	100	39·37

Table XV.—Square Inches to Square Centimetres

Sq. In.	Sq. Cm.	Sq. In.	Sq. Cm.
1	6·45	60	387·10
2	12·90	70	451·61
3	19·35	80	516·13
4	25·81	90	580·64
5	32·26	100	645·2
6	38·71	200	1290·3
7	45·16	300	1935·5
8	51·61	400	2580·6
9	58·08	500	3225·8
10	64·52	600	3871·0
20	129·03	700	4516·1
30	193·55	800	5161·3
40	258·06	900	5806·4
50	322·58	1000	645·6

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Table XVI.—Square Centimetres to Square Inches

Sq. Cm.	Sq. In.	Sq. Cm.	Sq. In.
1	0·155	200	31·00
2	0·310	300	46·50
3	0·465	400	62·00
4	0·620	500	77·50
5	0·775	600	93·00
6	0·930	700	108·50
7	1·085	800	124·00
8	1·240	900	139·50
9	1·395	1000	155·0
10	1·550	1500	232·5
20	3·10	2000	310·0
30	4·65	3000	465·0
40	6·20	4000	620·0
50	7·75	5000	775·0
60	9·30	6000	930·0
70	10·85	7000	1085·0
80	12·40	8000	1240·0
90	13·95	9000	1395·0
100	15·50	10,000	1550·0

Table XVII.—Grains into Grams

Grains	Grams	Grains	Grams	Grains	Grams
1	0·065	20	1·296	75	4·860
2	0·13	21	1·361	80	5·184
3	0·194	22	1·426	85	5·508
4	0·259	23	1·490	90	5·832
5	0·324	24	1·555	95	6·156
6	0·389	25	1·620	100	6·480
7	0·454	26	1·685	150	9·72
8	0·518	27	1·750	200	12·96
9	0·583	28	1·814	250	16·20
10	0·648	29	1·880	300	19·44
11	0·713	30	1·944	400	25·92
12	0·775	35	2·268	500	32·40
13	0·842	40	2·592	600	38·88
14	0·907	45	2·916	700	45·36
15	0·972	50	3·240	800	51·84
16	1·037	55	3·564	900	58·32
17	1·102	60	3·888	1000	64·80
18	1·166	65	4·212	2000	129·6
19	1·232	70	4·536	3000	194·4

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Table XVIII.—Avoirdupois or American Ounces to Grams

Ounces	Grams	Ounces	Grams	Ounces	Grams
⅛	3·54	3¾	106·31	8¼	233·89
¼	7·09	4	113·40	8½	240·90
⅜	10·63	4¼	120·49	8¾	248·07
½	14·18	4½	127·58	9	255·15
⅝	17·72	4¾	134·66	9½	269·33
¾	21·26	5	141·75	10	283·50
⅞	24·81	5¼	148·84	10½	297·68
1	28·35	5½	155·93	11	311·85
1¼	35·44	5¾	163·01	11½	326·03
1½	42·53	6	170·10	12	340·20
1¾	49·61	6¼	177·19	12½	354·38
2	56·70	6½	184·28	13	368·55
2¼	63·79	6¾	191·36	13½	382·73
2½	70·88	7	198·45	14	396·90
2¾	77·96	7¼	205·54	14½	411·08
3	85·05	7½	212·63	15	425·25
3¼	92·14	7¾	219·71	15½	439·33
3½	99·23	8	226·80	16	453·40

Table XIX.—Apothecaries Ounces to Grams

Ounces	Grams	Ounces	Grams	Ounces	Grams
⅛	3·89	3¾	116·64	8¼	256·61
¼	7·78	4	124·42	8½	264·38
⅜	11·66	4¼	132·19	8¾	272·16
½	15·55	4½	139·97	9	279·94
⅝	19·44	4¾	147·74	9½	295·49
¾	23·33	5	155·52	10	311·04
⅞	27·22	5¼	163·30	10½	326·59
1	31·104	5½	171·07	11	342·14
1¼	38·88	5¾	178·85	11½	357·70
1½	46·66	6	186·62	12	373·25
1¾	54·43	6¼	194·40	12½	388·80
2	62·21	6½	202·18	13	404·35
2¼	69·98	6¾	209·95	13½	419·90
2½	77·76	7	217·73	14	453·46
2¾	85·54	7¼	225·50	14½	451·01
3	93·31	7½	233·28	15	466·56
3¼	101·09	7¾	241·06	15½	482·11
3½	108·86	8	248·83	16	497·66

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Table XX.—Grams to Grains

Grams	Grains	Grams	Grains	Grams	Grains
0·1	1·5	10	154	65	1003
0·2	3·1	11	170	70	1080
0·3	4·6	12	185	75	1157
0·4	6·2	13	201	80	1235
0·5	7·7	14	216	85	1312
0·6	9·2	15	231	90	1389
0·7	10·8	16	247	100	1543
0·8	12·3	17	262	110	1698
0·9	13·9	18	278	120	1852
1	15·4	19	293	130	2006
1·5	23·1	20	309	140	2160
2	30·9	25	386	150	2314
3	46·3	30	463	160	2469
4	61·7	35	540	170	2624
5	77·2	40	617	180	2778
6	92·6	45	694	190	2932
7	108	50	772	200	3086
8	123	55	849	250	3858
9	139	60	926	300	4628

Table XXI.—Grams into Avoirdupois Ounces and Grains

Grams	Oz.	Grains	Grams	Oz.	Grains
30	1	26	120	4	102
35	1	103	125	4	179
40	1	180	130	4	256
45	1	257	140	4	410
50	1	335	150	5	127
55	1	412	160	5	282
60	2	51	170	5	436
65	2	128	180	6	153
70	2	205	190	6	307
75	2	282	200	7	24
80	2	360	250	8	358
85	3	0	300	10	253
90	3	78	350	12	150
95	3	154	400	14	47
100	3	231	450	15	380
110	3	386	500	17	279

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Table XXII.—Grams into Apothecaries Ounces and Grains

Grams	Oz.	Grains	Grams	Oz.	Grains
35	1	60	120	3	412
40	1	137	130	4	86
45	1	214	140	4	240
50	1	292	150	4	394
55	1	369	160	5	69
60	1	446	170	5	224
65	2	43	180	5	378
70	2	120	190	6	52
75	2	197	200	6	206
80	2	275	250	8	18
85	2	352	300	9	308
90	2	429	350	11	120
95	3	26	400	12	412
100	3	103	450	14	222
110	3	258	500	16	36

Table XXIII.—English Minims, Drachms and Fluid Ounces to C.C.

Minims	C.C.	Drachms	C.C.	Ounces	C.C.
1	0·059	1	3·55	1	28·41
2	0·118	2	7·10	1½	42·6
3	0·178	3	10·65	2	56·8
4	0·237	4	14·21	3	85·2
5	0·296	5	17·76	4	113·6
6	0·355	6	21·31	5	142·0
7	0·414	7	24·86	6	170·5
8	0·474	8	28·41	7	198·9
9	0·533			8	227·3
10	0·592			9	255·7
15	0·89			10	284·1
20	1·18			11	312·5
25	1·48			12	340·9
30	1·77			13	269·4
35	2·07			14	397·8
40	2·37			15	426·2
45	2·66			16	454·6
50	2·96			17	483·0
55	3·26			18	511·4
60	3·55			19	539·8
				20	568·2

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Table XXIV.—American Minims, Drachms and Fluid Ounces to C.C.

Minims	C.C.	Drachms	C.C.	Ounces	C.C.
1	0·062	1	3·70	1	29·57
2	0·123	2	7·39	2	59·15
3	0·185	3	11·09	3	88·72
4	0·246	4	14·79	4	118·3
5	0·308	5	18·48	5	147·9
6	0·370	6	22·18	6	177·4
7	0·431	7	25·88	7	207·0
8	0·493	8	29·57	8	236·6
9	0·555			9	266·2
10	0·616			10	295·7
20	1·232			12	354·9
30	1·848			14	414·0
40	2·465			16	473·2
50	3·081			The U.S.A. Pint is 16 ounces.	
60	3·697				

Table XXV.—American Minims, Drachms and Fluid Ounces to English Minims, Drachms and Fluid Ounces

Amer. Minims	English Minims	Amer. Drachms	English Drachms and Minims		Amer. Fl. Oz.	English Fl. Oz. and Minims	
1	1·04						
2	2·08		dr.	min.		oz.	min.
3	3·12	1	1	2½	1	1	19½
4	4·16	2	2	5	2	2	39
5	5·20	3	3	7½	3	3	59
6	6·25	4	4	10	4	4	78½
7	7·29	5	5	12	5	5	98
8	8·33	6	6	14½	6	6	118
9	9·37	7	7	17	7	7	137
10	10·41	8	8	19½	8	8	157
20	20·82				9	9	177
30	31·23				10	10	196
40	41·64				12	12	236
50	52·05				14	14	275
60	62·45				16	16	314
					20	20	393
					32	33	148

Note :—U.S.A. pint is 16 oz. American; U.S.A. quart is 32 oz. American; U.S.A. gallon is 128 oz. American.

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Table XXVI.—C.C. into English Fluid Ounces and Minims

C.C.	Oz.	Min.	C.C.	Oz.	Min.	C C.	Oz.	Min.
0·1		1·7	55	1	449	350	12	153
0·2		3·4	60	2	54	375	13	95
0·3		5·1	65	2	138	400	14	37
0·4		6·8	70	2	223	425	14	460
0·5		8·5	75	2	307	450	15	402
0·6		10·1	80	2	392	475	16	345
0·7		11·8	85	2	476	500	17	287
0·8		13·5	90	3	81	525	18	230
0·9		15·2	95	3	165	550	19	172
1		16·9	100	3	250	575	20	114
2		33·8	110	3	418	600	21	56
3		50·7	120	4	107	625	22	0
4		67·6	125	4	192	650	22	421
5		84·5	130	4	276	675	23	364
6		101·4	140	4	445	700	24	306
7		118·3	150	5	134	725	25	248
8		135·2	160	5	303	750	26	190
9		152	170	5	472	775	27	133
10		169	175	6	76	800	28	75
15		253	180	6	161	825	29	18
20		338	190	6	330	850	29	440
25		422	200	7	20	875	30	382
30	1	27	225	7	441	900	31	325
35	1	111	250	8	384	925	32	267
40	1	196	275	9	326	950	33	210
45	1	280	300	10	268	975	34	152
50	1	365	325	11	210	1000	35	94

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TABLE XXVII.—GRAINS OR GRAMS OF CRYSTALLINE SODIUM CARBONATE TO GRAINS OR GRAMS OF ANHYDROUS CARBONATE

Cryst.	*Anhydr.*	*Cryst.*	*Anhydr.*	*Cryst.*	*Anhydr.*
5	1·85	75	27·78	600	222·3
6	2·22	80	29·64	700	259·3
8	2·96	90	33·34	800	296·4
10	3·70	100	37·05	900	333·4
15	5·56	120	44·45	1000	370·5
20	7·41	140	51·86	1500	555·7
25	9·26	160	59·27	2000	740·9
30	11·11	180	66·68	3000	1111
35	12·9	200	74·09	4000	1482
40	14·82	250	92·61	5000	1852
45	16·67	300	111·1	6000	2223
50	18·52	350	129·7	7000	2593
55	20·37	400	148·2	8000	2964
60	22·23	450	166·7	9000	3334
70	25·93	500	185·2	10000	3705

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Table XXVIII.—Ounces of Crystalline Sodium Carbonate to Ounces and Grains of Anhydrous Carbonate

Crystalline	*Anhydrous*	*Crystalline*	*Anhydrous*
Oz. (Av. or Amer.)	Oz. (Av.) and Grains	Oz. (Apoth.)	Oz. (Apoth.) and Grains
¼	— 40·5	¼	— 44·5
½	— 81·0	½	— 88.9
¾	— 121·6	¾	— 133·4
1	— 162·1	1	— 177·8
1¼	— 202·6	1¼	— 222·3
1½	— 243·1	1½	— 266·7
1¾	— 283·6	1¾	— 311·2
2	— 324·2	2	— 355·6
2¼	— 364·7	2¼	— 400·1
2½	— 405·2	2½	— 444·5
2¾	1 8	2¾	1 9
3	1 49	3	1 53
3¼	1 89	3¼	1 98
3½	1 130	3½	1 142
3¾	1 170	3¾	1 187
4	1 211	4	1 231
4¼	1 251	4¼	1 276
4½	1 292	4½	1 320
4¾	1 332	4¾	1 365
5	1 373	5	1 409
5¼	1 413	5¼	1 454
5½	2 16	5½	2 18
5¾	2 57	5¾	2 62
6	2 97	6	2 107
6¼	2 138	6¼	2 151
6½	2 179	6½	2 196
6¾	2 219	6¾	2 240
7	2 260	7	2 285
7¼	2 300	7¼	2 329
7½	2 341	7½	2 374
7¾	2 381	7¾	2 418
8	2 422	8	2 463

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Table XXIX.—Grains or Grams of Anhydrous Sodium Carbonate to Grains or Grams of Crystalline Carbonate

Anhydrous	*Crystals*	*Anhydrous*	*Crystals*	*Anhydrous*	*Crystals*
5	13½	80	216	375	1012
8	21½	90	243	400	1080
10	27	100	270	425	1147
15	40½	120	324	450	1215
20	54	140	378	500	1350
25	67½	160	432	600	1620
30	81	180	486	700	1890
35	94½	200	540	800	2160
40	108	225	607	900	2430
45	121	250	675	1000	2700
50	135	275	742	2000	5399
55	148	300	810	3000	8099
60	162	325	877	4000	10798
70	189	350	945	5000	13498

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Table XXX.—Ounces of Anhydrous Sodium Carbonate to Ounces and Grains of Crystalline Carbonate

Anhydrous	*Crystalline*		*Anhydrous*	*Crystalline*	
Oz. (Av. or Amer.)	Oz. (Av.)	and Gr.	Oz. (Apoth.)	Oz. (Apoth)	and Gr.
¼	—	295	¼	—	324
½	1	153	½	1	168
¾	2	11	¾	2	12
1	2	306	1	2	336
1¼	3	164	1¼	3	180
1½	4	22	1½	4	24
1¾	4	317	1¾	4	348
2	5	175	2	5	192
2¼	6	32	2¼	6	35
2½	6	328	2½	6	359
2¾	7	185	2¾	7	203
3	8	43	3	8	47
3¼	8	338	3¼	8	371
3½	9	196	3½	9	215
3¾	10	54	3¾	10	59
4	10	349	4	10	383
4¼	11	207	4¼	11	227
4½	12	65	4½	12	71
4¾	12	360	4¾	12	395
5	13	218	5	13	239
5¼	14	76	5¼	14	83
5½	14	371	5½	14	407
5¾	15	229	5¾	15	251
6	16	86	6	16	95

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Makeshift Weights.

Coins as Weights.—In the absence of proper weights, coins may be pressed into service. The weight of the various coins is given in Table XXXI

Table XXXI.—Weights of Coins

Coins	Grams	Grains
Threepenny piece (silver) . .	1·41	21·8
Sixpence	2·83	43·6
Shilling	5·65	87·2
Florin	11·38	175·4
Half-Crown	14·11	218
Farthing	2·84	43·75
Halfpenny	5·66	87·5
Penny	9·44	145·8
Threepenny piece (nickel-brass)	7·80	105·0

Even fractions of an ounce may be made up as follows :—

¼ oz. (Avoir.) = one halfpenny and one silver threepenny piece.

½ oz. (Avoir.) = two halfpennies and a farthing.

1 oz. (Avoir.) = three pennies (or five halfpennies).

The weights given for coins apply with exactitude only to those that are new and unworn.

Copper Wire.—The needs of the electrical industry have resulted in the production of copper wire of a high standard of uniformity. By simply measuring off suitable lengths of enamelled copper wire of the correct gauge, quite accurate weights may be prepared. Tables XXXII and XXXIII give the lengths required for weights of convenient values both in grams and grains. Higher accuracy is obtainable by choosing the thinner wire where the tables give alternatives; quite a long length of 30 or 24 s.w.g. wire can be rolled up into a small space. 18-gauge wire is too stiff to roll up readily, though it can be doubled easily enough by bending; 12-gauge wire is really a thin rod. It is best dealt with by cutting into short lengths, finally binding these into a bundle with 30-gauge wire. The weight of the binding-wire can easily be allowed for by cutting the thick wire a shade short.

If working in grams, a set of weights should include 0·01, 0·02, 0·05, 0·1, 0·2, 0·5, 1, 2, 5, 10 and 20 gm., and two each of the 0·01, 0·1, 1 and 10 gm. weights should be made.

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If working exclusively in grains, a corresponding set would be ½, 1, 2, 5, 10, 20, 50, 100, 200 and 500 grains, and again should include two each of 1, 10 and 100-grain weights. Scruples, drachms, quarter-ounces, half-ounces, and ounces can be added if required.

TABLE XXXII.—LENGTHS OF ENAMELLED COPPER WIRE FOR USE AS METRIC WEIGHTS

Weight in gm.	30 s.w.g., cm.	24 s.w.g., cm.	18 s.w.g., cm.	12 s.w.g., cm.
0·01	1·43	0·45	—	—
0·02	2·84	0·89	—	—
0·05	7·13	2·24	0·47	—
0·1	14·28	4·48	0·94	—
0·2	28·4	8·94	1·89	0·40
0·5	71·3	22·4	4·72	1·01
1	142·8	44·8	9·41	2·02
2	285·6	89·6	18·9	4·04
5	—	224	47·2	10·11
10	—	—	94·1	20·2
20	—	—	188·2	40·4
50	—	—	—	101
100	—	—	—	202

TABLE XXXIII.—LENGTHS OF ENAMELLED COPPER WIRE FOR USE AS ENGLISH WEIGHTS

Weights in grains.	30 s.w.g. (inches)	24 s.w.g. (inches)	18 s.w.g. (inches)	12 s.w.g. (inches)
¼	0·91	—	—	—
½	1·82	0·576	—	—
1	3·63	1·14	—	—
2	7·26	2·28	0·48	—
5	18·18	5·72	1·21	—
10	36·35	11·43	2·41	0·51
20 (1 scruple)	72·6	22·95	4·82	1·03
30 (½ drachm)	109	34·33	7·23	1·47
50	181·8	57·15	12·08	2·58
60 (1 drachm)	—	68·65	14·47	3·09
80	—	91·5	19·31	4·12
100	—	114·3	24·15	5·15
109⅜ (¼ oz. Av.)	—	125·1	26·38	5·64
120 (¼ oz. Apoth.)	—	137·1	28·9	6·17
200	—	—	48·2	10·3
218¾ (½ oz. Av.)	—	—	52·8	11·28
240 (½ oz. Apoth.)	—	—	57·9	12·35
437½ (1 oz. Av.)	—	—	—	22·55
480 (1 oz. Apoth.)	—	—	—	24·7

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Weights carefully made from copper wire can be relied upon within very close limits, and are fully accurate enough for all photographic work. Their accuracy, however, is only retained as long as they are substantially uncorroded.

Wellington Intensifier. See INTENSIFICATION.

Weston Speeds. See *Conversions between the Older Systems* under SENSITOMETRY.

Wet Collodion Process. Either negatives or positives can be produced ; and the latter, when taken upon thin enamelled-iron plates, are known as ferrotypes or tintypes. The following is a short *résumé* of the process :—A well-cleaned glass plate is coated with iodised collodion, and as soon as the collodion has set, this coated plate is immersed in a bath made as follows :—

Silver nitrate . . .	240 gr.	(24 gm.)
Potassium iodide . . .	1 gr.	(0·1 gm.)
Distilled water . . .	8 oz.	(350 c.c.)

Dissolve the silver salt in 2 oz. (100 c.c.) of water, and the potash in ½ oz. (25 c.c.). Add the latter to the former, and add the remainder of the water. Filter, and test for acidity. If blue litmus paper is not turned red after an immersion of some short period, a few drops of a dilute nitric acid (1 in 12) should be added till the bath is decidedly acid. The plate is exposed whilst still wet, reckoning the speed of the plate as about 5 H. & D. For development either of the following may be used :—

No. 1.

Ferrous sulphate . . .	½ oz.	(25 gm.)
Glacial acetic acid . . .	½ oz.	(25 c.c.)
Methylated spirit . . .	½ oz.	(25 c.c.)
Distilled water . . .	10 oz.	(500 c.c.)

No. 2.

(For short exposure and detail.)

Ferrous sulphate . . .	300 gr.	(34 gm.)
Glacial acetic acid . . .	200 min.	(23 c.c.)
Formic acid (sp. gr. 1·060) .	100 min.	(11·5 c.c.)
Methylated spirit . . .	240 min.	(27·5 c.c.)
Distilled water . . .	10 oz.	(500 c.c.)

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Wetting Agent

No. 3.

(*For long exposure and contrast.*)

Ferrous sulphate . . .	200 gr.	(23 gm.)
Glacial acetic acid . . .	180 min.	(20 c.c.)
Lump sugar . . .	100 gr.	(11·5 gm.)
Methylated spirit . . .	240 min.	(27·5 c.c.)
Distilled water . . .	10 oz.	(500 c.c.)

To develop the exposed plate, it should be fixed upon a pneumatic holder and a little of the developer poured evenly on to the surface and gently rocked backwards and forwards till the image is sufficiently developed, when it may be poured off. The image nearly always requires intensification for negative work, and the following may be used :—

Ferrous sulphate . . .	5 gr.	(1·15 gm.)
Citric acid	10 gr.	(2·3 gm.)
Distilled water . . .	1 oz.	(100 c.c.)

Add immediately before using a few drops of—

Silver nitrate . . .	10 gr.	(2·3 gm.)
Distilled water . . .	1 oz.	(100 c.c.)

Pour on to the unfixed negative, and rock backwards and forwards till dense enough. Then fix in—

Potassium cyanide . .	120 gr.	(13·5 gm.)
Distilled water . . .	10 oz.	(500 c.c.)

Wash thoroughly, dry, and varnish.

See also COLLODION PROCESSES.

Wetting Agent. Substance which, when added to water in small quantity, reduces its surface tension, so enabling the water to run freely over a surface and wet it evenly without forming drops. Wetting agent in a developer ensures even and instant wetting of the film and absence of airbells, while in the final wash-water it causes the adherent water to run smoothly off the film when hung up to dry, ensuring more rapid drying and absence of drying marks. Added to dyes or tints it enables them to " take " readily on the gelatine of even a dry print.

Wide Angle. Term applied to a lens embracing an angle of view that is wider than usual. As the usual angle of view is that given by a lens the focal length of which is roughly equal to the diagonal of the negative, any lens of shorter focal length than this is classed as a wide-angle lens. A lens of

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focal length 3 in. would be classed as a long-focus lens when used on a 24 × 36 mm. negative (diagonal = $1\frac{3}{4}$ in.) as a lens of normal focal length when used on a $2\frac{1}{4}$-in. sq. negative (diagonal = 3·2 in.), and as a wide-angle lens when used on a quarter-plate (diagonal = $5\frac{1}{4}$ in.).

As a photograph is only seen in correct perspective when viewed from a distance equal to the focal length of the lens with which it was taken (see DISTORTION and PERSPECTIVE), the usual rather "exaggerated" perspective common to most photographs is enhanced when a wide-angle lens is used. Nevertheless, it has to be used when it is necessary to include the whole of a subject from an inconveniently near standpoint.

A defect common to all wide-angle lenses is a falling-off in illumination towards the margin of the picture. Apart from any cut-off due to the mount, or to a lens-hood or other accessory, this is an inevitable consequence of the greater distance of the margins of the field from the lens, and of the fact that at the margins the light strikes the plate obliquely. If the illumination at the centre of the field is taken as 100, that at increasing angles from the centre is as given in the following table from Clerc's *Photography*.

Angle	0°	10°	20°	30°	40°	50°	60°
Illumination	100	94·1	78·0	56·2	34·4	17·1	6·2

Experience shows that illumination may fall off to 80 per cent. of the maximum without becoming noticeable, and that even a reduction to 60 per cent. is quite tolerable. These limits correspond to a *total* field of view of 36° and 56° respectively, obtained by using lenses of focal length 6·6 inches or 4·05 inches respectively on a $3\frac{1}{2}$ × $2\frac{1}{2}$ plate. The falling-off in illumination must thus always be noticeable when a lens of fairly wide angle is used. Of current sizes, that embracing the widest angle is the 6 x 6 cm. size, with which a 7·5 cm. lens is almost always used (total angle = 59°), and on such negatives "dark corners" are common. They are usually very noticeable on contact prints, but on enlarging with a lens of 7·5 cm. or less focus, the loss of illumination towards the corners of the paper tends to correct the fault.

Under-exposed corners are always less marked if full exposure is given, and in that case any darkening towards the corners of the print can be offset in enlarging or printing by suitable shading.

Wide-Angle Lens. See WIDE-ANGLE above; also LENS and ANGLE OF VIEW.

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Wire Release. See SHUTTER RELEASES.

Wood, Photographs on. A method of printing photographs upon wood is as follows : First coat the wood, on which the print is to be made, with the following solution :—

Gelatine	1 part
Water (warm)	25 parts

to which is added sufficient zinc white to practically hide the grain of the wood when coated.

When dry, brush over the surface with a solution of—

Kitchen salt	1 part
Water	10 parts

Dry again, and then, in the dark-room, sensitise with 10 per cent. silver nitrate solution by application with a camel's-hair mop or Blanchard brush.

When the wood is weakly printed the image must be developed with the following :—

Metol	1·5 gr.	(0·1 gm.)
Acetic acid	30 min.	(2 c.c.)
Water	3½ oz.	(100 c.c.)

When the image is dark enough, it is rinsed and fixed.

If the print is being made on wood for the purpose of making a wood block, a reversed negative must be used. (See REVERSED NEGATIVE.)

Carbon prints can also be transferred to prepared wood surfaces. (See CARBON ; also TRANSFEROTYPE.)

Woodburytype. This is a very beautiful photo-mechanical process, and consists of exposing a thick film of bichromated gelatine to light under a negative ; and when fully exposed it is washed to dissolve the unacted-upon soluble portions, and after being soaked in alum is dried. When dry, the gelatine print, which at this period looks like a delicate piece of silk with the image in relief, is placed on to a bed of metal, and a pressure of from four hundred to five hundred tons per square inch is brought to bear on it. This forces the gelatine into the metal, and makes an impression just as does a seal on hot sealing wax, the film of gelatine itself beingnha urmed and used over and over again. The metal sheet bearing an impression now becomes a mould, and this is placed in a press, and some special liquid gelatine ink is poured on to it, and a sheet of non-absorbent paper placed over. The press is now

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closed, and pressure being applied, it is obvious that the ink will leave the high lights and collect in the shadows. When the gelatine ink has set, the paper is removed, bearing the image, and is fixed in alum and dried.

Wood Spirit or Wood Naphtha. This is a crude form of methyl alcohol (see ALCOHOL, METHYL), and is used in the preparation of methylated spirit. The crude wood spirit is sometimes used instead of alcohol as a solvent in varnish-making, and in certain concentrated developers.

Working up Prints. See COLOURING PHOTOGRAPHS and FINISHING PRINTS: also ENLARGING. BROMIDE PAPER, and AIR BRUSH.

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X

X-Ray Photography. See RADIOGRAPHY.

X-Synchronization. Flash synchronization so arranged that the contact necessary to fire the flash is made just as the shutter reaches the full-open position. See *Synchronization* under FLASHGUN.

Xylonite. Another name for celluloid (*q.v.*).

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Y

Yellow Filter or Screen. See FILTER; also see SAFE-LIGHT.

Yellow Stain. See STAINS.

Yellowness of Prints. See TONING. See also STAINS, BROMIDE PAPER, and FADING.

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Z

Zincography. See PHOTO-MECHANICAL PRINTING PROCESSES.

Zone Focusing. A method of focusing suitable for small or simple cameras. Instead of focusing on the known or estimated distance of the object, focusing is set for a zone that includes it. There may be three settings, marked "Landscape", "Group" and "Portrait". A fully scaled camera may, of course, be used in this way, especially at the smaller stops.

Zoom Lens. A lens the focal length of which can be altered continuously, without change in focusing setting or effective aperture. Zoom lenses have been used for some time in television and cine cameras, in which connection they are frequently used to give the effect of a tracking shot; a group of figures may be shown for a second or so, and then the zoom lens is increased in focal length so that the image grows until eventually only the head and shoulders of one person fills the screen. Equally, of course, the lens may be set, before the sequence starts, to give exactly the desired field of view. More recently zoom lenses have been introduced for still cameras—primarily for single-lens reflexes—to enable the intended subject to be exactly framed. Exact framing is not very important in monochrome or colour negative work, where it is always possible to enlarge from part only of a negative, but for the making of colour transparencies a zoom lens is an invaluable tool.

A zoom lens is a complicated, and consequently expensive, instrument, consisting usually of twelve or more components; the change in focal length is obtained by moving one group of components with respect to the rest. The first zoom lens for a miniature camera, the Voigtländer Zoomar, gave focal

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lengths from 36 to 82 mm., and worked at a maximum aperture of *f*/2·8.

Zoo Photography. The increase in the number of zoological gardens in recent years has helped to popularise the photography of animals in captivity, and in Britain nearly all these zoos permit photographers to use hand cameras and substandard cine cameras on their premises. The only restrictions imposed are those that apply also to non-photographers, such, for example, as forbidding them to climb over barriers.

When the zoological gardens are privately owned (that is, owned by a private citizen or a commercial company) or belong to a scientific society (as do the zoos at London, Edinburgh and Dublin), enquiry should always be made as to possible restrictions on the photography of certain exhibits. Municipal and state-owned zoos usually tell visitors the position by notices at the gate.

From the photographer's point of view no two zoos are alike, and the differences in lay-out and arrangement of the exhibits make some subjects difficult in one zoo and comparatively easy in another. For example, the polar bears on the open-fronted Mappin Terraces in Regent's Park are easy subjects for the camera ; at Whipsnade, where the bears are surrounded by tall iron railings with an iron-work barrier outside them. the bears are difficult to photograph well, unless the photographer makes friends with a member of the menagerie staff and is taken inside that outer barrier.

The chief problem of the photographer who seeks good pictures is the presence of the various bars and barriers ; these, and their shadows, spoil animal portraiture. So do the ugly backgrounds.

Fine-mesh netting such as is used to confine birds and some of the less powerful animals need be no obstacle. If the camera has a lens of aperture *f*/4·5 or *f*/6·3, and the photographer is able to press his lens firmly against those wires, they will not appear in the negative. Hold the camera 12 or 16 inches or more away from the netting, and it shows as an out-of-focus pattern over all the negative ; but when the lens is pressed close against the wires they are so far out of focus that they fade out of the picture entirely. This applies to thin-gauge wire netting, and not to stout iron bars.

In London, Bristol, and Dublin and other zoos, lions, tigers and leopards are kept behind stout bars, and there is only one way of dodging those bars—the photographer must persuade a

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keeper in that section to take him inside the outer barrier so that he can poke his lens between the bars, while the animal is kept in control by the keeper, whom he knows and trusts.

At Whipsnade, Edinburgh and Dudley zoos some of the lions are in enclosures, which gives the photographer a chance to point his camera through the fencing with a clear field of view, while the camera (and its holder) is well out of the animal's reach. But that generally means that the lion or tiger is a long way off—say 20 ft. or 40 ft., a fact which means a small image on the plate if a lens of normal focal length is used. For such work as this the modern telephoto lens is ideal, and much of the best animal photography in such cases is done with a lens of focal length from two to three times the diagonal of the negative, preferably used in a reflex camera.

If some subjects in a zoo are difficult, others are as easy as any other kind of snapshotting. Elephants out of their homes and walking along the zoo paths ; camels on the paths or on a lawn ; monkeys in large and accessible cages, and large birds in big aviaries—these are as easy to take as a cart-horse in a field.

Houses with a dark interior, such as some of the reptiliaries and the aquariums, in which the creatures are viewed by artificial light, are admittedly difficult subjects, and many of the best pictures of these are taken on fast pan film by miniature cameras using *f*/1·5 or *f*/2 lenses, with slow automatic exposures which are successful only when the creatures are still.

Amateur workers inexperienced in the difficulties of zoo work will find their best subjects in the open enclosures, but there, even with easy subjects such as sitting bears and wolves, camels, antelopes, bison, eagles and vultures, they often come up against the problem of the bad background. One way out is to choose a moment when partial back lighting (with the sun at the photographer's right or left front) throws the background into shadow and helps the creature itself to stand out clearly, with its outlines edged by the bright light.

A good zoo portrait requires (1) a good negative, obtained by generous exposure and development suited to the paper to be used ; (2) satisfactory rendering of texture of fur or feather ; (3) good modelling of the creature—that is " correct drawing."

The last point is important. By " correct modelling " is meant the shape of the creature, and the avoidance of a distorted rendering. You can distort the shape of an animal's head by pointing the camera steeply upwards in a close-up ; or

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by taking an " end-on " animal with the creature too near the camera, so that you get the head of a cat and the haunches of a young kitten. (See PERSPECTIVE and DISTORTION.)

Reflex cameras are the regular outfit of the zoo photographer of experience, but some of the newer generation have adopted the miniature camera with a big-aperture lens and at least one long-focus lens.

Amateurs who undertake a little " free-lance " work in the hope of selling pictures for reproduction should note that there is always a demand for first-class zoo studies of the more interesting creatures. (See also NATURE PHOTOGRAPHY.)

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